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AUTHOR Butzow, John W.; And Others
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ABSTRACT

Classroom and field activities for fifth- through ninth-grade students comprise this teaching guide for the northern New England shore. Teacher background information contains an introduction to life at the shore and the animal classification of marine invertebrates. Activities stress two major concepts: (1) the diversity and complex interactions of marine organisms; and (2) the structural, functional, and behavioral adaptations these organisms make to the shore environment. Topics of classroom activities include saltwater aquariums, seashore life, seaweeds, and a field trip bulletin board. Field activities involve pre-trip planning, beach profiling, exploring for green crabs, and critter watching. Each activity identifies the objective, field site when appropriate, materials, timing, and procedure. Lists of organizational resources, resource persons, places to visit, films, and books are provided for the unit. Informational sheets are also included. (DC)

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Have You Been to the Shore Before?

A Marine Education Infusion Unit on Seashore and Aquarium Life

Units Revision Team

John W. Butzow, *Project Director*

Peter Corcoran, *Curriculum Writer and Assistant Director*

Susan White, *Educational Materials Design and Production*

Dimitry Schidlovsky, *Illustration*

Northern New England Marine Education Project

The objective of NNEMEP is to encourage and support marine education among the teachers of Northern New England so that their students will appreciate the importance of water in their lives and in the life of the planet. The project has received support from the College of Education of the University of Maine at Orono, the National Science Foundation, and the Maine-New Hampshire Sea Grant Program.

206 Shibles Hall
College of Education
University of Maine
Orono, Maine 04469

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Contributors

NNEMEP Staff

Project Director: John Butzow 1975-81
Project Assistant Directors:
- Richard Schlenker 1976-77
- Les Picker 1977-78
- Harry H. Dresser 1978-79
- Peter Corcoran 1979-81

Major Contributors:
- John Butzow
- Clayton Carkin
- Peter Corcoran
- Victor DiSilvestro
- Harry Dresser
- John Eiseman
- Richard Glueck
- Ruth Gruninger
- Deborah Hartney
- Wesley Hedlund
- Mildred Jones
- Win Kelley
- Steven Kilfoyle
- Daniel Lancor
- Jean MacConnell
- Julia Steed Mawson
- Les Picker
- Robert Pratt
- Gail Shelton
- Lorraine Stubbs

Staff Assistants:
- Julie Brown
- Deborah Hartney
- Heidi Richards
- Michael Shirley

Developmental Art Work:
- Peter Archambault
- Lori Dombek
- Carol Nichols
- Harry Dresser
- William Hepburn

Developmental Photography:
- Les Picker
- John Butzow
- Clarence Barber

Manuscript Preparation:
- Mary Brown

Revised Marine Education Infusion Units for Middle School-Junior High School

Have You Been to the Shore Before? A Marine Education Infusion Unit on Seashore and Aquarium Life

What Adventures Can You Have in Wetlands, Lakes, Ponds, and Puddles? A Marine Education Infusion Unit on Wet Environments

What is Our Maritime Heritage? A Marine Education Infusion Unit on Ships and Shipping

Is Our Food Future in the Sea? A Marine Education Infusion Unit on Aquaculture and Sea Farming

How Do People Use Lighthouses and Navigational Charts? A Marine Education Infusion Unit

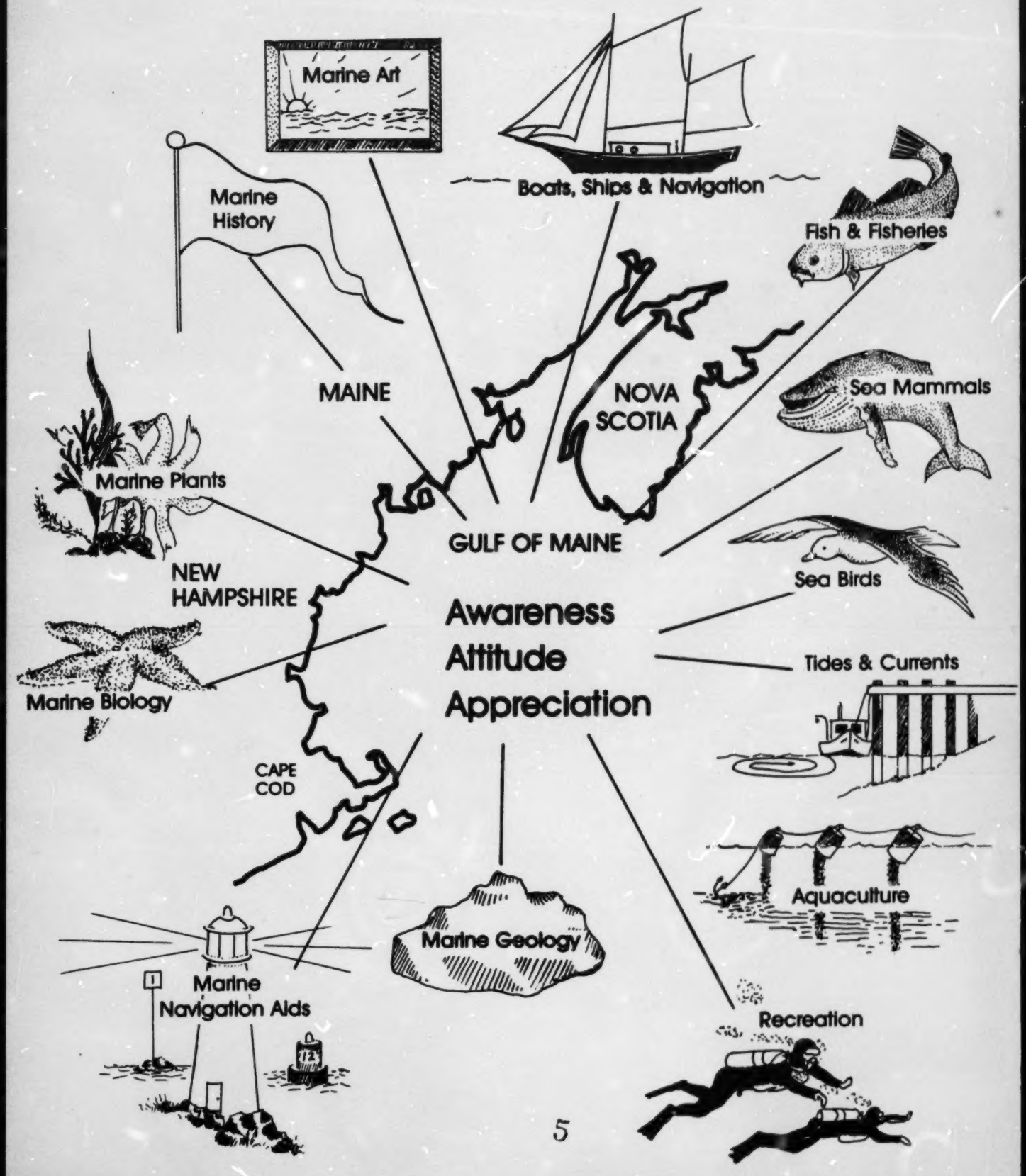
Original — Trial Editions (For Grades K-12)

Clams and Other Critters
Marine Art
The Aquarium
The Beaver
The Lobster
Whale Multi-disciplinary Studies
Our Heritage of Ships
Shipping, Ships and Waterways
The ABCs of Celebrating Year of the Coast in Your School
Have You Ever Been to the Shore Before?
Blue Mussel
Lighthouses
Wetlands
Seaweeds
Aquaculture
Navigation

More than one hundred teachers and members of past NSF sponsored summer institutes have trial tested and critiqued these units.

Marine Education

Ocean & Coast Conceptual Scheme



Foreword

Marine education is a relatively new term embracing a multi-disciplinary approach to learning about the marine environment: how it relates to people and how people change and relate to it. These units are intended to serve as points of departure for teachers and students who desire to increase their awareness of the watery world of this blue planet. Each unit includes ideas and activities drawn from a variety of content areas so that teachers of many different subjects at the junior high and middle school levels can make use of them. These units may be used in their entirety or used as idea or activity sources to infuse into the usual curriculum.

Our objective is to help teachers make learning more water-related. We did not plan a structural sequence of topics for grades 5-9 but rather offer these teachers guides and student pages for your consideration.

The general focus within these units is the Gulf of Maine. As the Gulf extends from Cape Cod to Nova Scotia it washes an extremely long and varied coast. We have dredged and seined themes from the activities, concerns, organisms, vessels, and the past of this vast watery region of North America. We aim to be inclusive rather than exclusive, suggestive rather than factual, and stimulating rather than expert. Our hope is that your students will become more questioning, interested, and critical of watery concerns. We hope your use of these materials will add water back into our culture.

John W. Butzow

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Teacher Background Information

The broad purpose of marine education is to develop a marine literate citizenry; that is to educate our students about the fundamental importance of the connections of human culture to the marine and aquatic environment. The general purpose of the marine education infusion units in this series is to provide teaching materials to make this broad purpose possible for middle and junior high school teachers in Northern New England. The special purpose of* Have You Been To The Shore Before? *is to make available teacher-tested ideas and activities for use in your classroom and in your field trips to the shore.

The important concepts in this unit are the diversity and complex interactions of marine organisms and the structural, functional, and behavioral adaptations these organims make to the shore environment. Specific objectives are given for each activity but bear in mind two general objectives. Students should develop improved knowledge and increased appreciation of the beauty and complex interrelatedness of life at the shore.

This unit is not a step by step piece of curriculum; it is designed to allow flexibility on your part. It will be necessary for you to adapt the material to your students' abilities and needs, your access to materials, and the availability of transportation for field trips.

The Northern New England Marine Education Project values teacher input. This unit will be introduced in workshops throughout the bistate region; we welcome your reactions and ideas for improvement. Feel free to contact us.

An Introduction to Life at the Shore

As the sea washes the land, it supplies moisture, shelter and food to organisms living on its edge called the shore. The amount of water which washes a section of shore during the course of a day is highly variable, depending on the tides that day, the wind, and the angle the shore makes with the sea. The type of material making up the shore provides varying amounts of security for shore dwellers.

In our region, we have semidiurnal tides which are two nearly equal high and low water conditions with approximately twelve hours between each period of high water. While our tides along the Maine and New Hampshire shore differ from west to east, they provide an average of ten feet of land, measured vertically, which is exposed at low water.

This part of the shore, which will be our major focus, is often teeming with life adapted to both wet and dry conditions. Sometimes, however, it is nearly devoid of life that you can see with the naked eye. A place where the sun bakes organisms part of the day and waves crash over them during the other part calls for tenants with special adaptations. Because of these conditions, living space is limited in this area. Creatures must be able to dig in, stick on, root in, or hang on to be able to live here.

The rounded pebble or shingle beach is made up of relatively small, wave-worn rocks which constantly move about. Since it provides little protection or safety, there are few life forms found on this type of shore. Sandy and muddy shores on the other hand offer good protection for some organisms, especially diggers. Mud, depending on its consistency, also offers possibilities for rooters while sand is usually too mobile for these organisms. Shores made up of large immobile rock faces provide a place for stickers, clingers, clutchers and, in the cracks, some rooters. Since the rock surface is generally impenetrable it wears its flora and fauna for all to see.

Life forms are for the most part intermingled throughout sandy and muddy shore areas. The animal life usually moves and digs in order to find better moisture conditions, to avoid crowds, or to obtain food. Although diggers may not be seen on the surface, bubbles in the moist sand or mud are an indication that they are underneath. No bands, zones, or other special regions are useful to those searching for life on these kinds of beaches. To find critters you need to imitate nature and dig too.

The angular face of the rocky shore remains remarkably unchanged although it is constantly exposed to the varying conditions of the sea. Creatures tend to congregate along the edge of the rock in bands parallel to the sea's edge. Where each organism chooses to live depends not only on its individual characteristics but also on the angle of the rock's surface to the sea, the presence or absence of shadows, and other environmental conditions which vary greatly from place to place.

Types of Shores

Basically, the shore is where the sea meets the land. Because of the variation in tides, this meeting point changes during the month. The best time to visit the shore is when there is a spring tide. This occurs when the tide is highest and lowest and takes place during a full moon or a new moon. Neap tides take place during the first and third quarters of the moon and represent the smallest changes in tide height. Therefore, if you visit the shore during spring tide you will be able to see the most plant and animal life since more of the shore is exposed then.

Four different shores are represented along the Maine and New Hampshire coasts. These are **rocky**, **shingle** (also called pebble), **sandy**, and **muddy**. In many cases, these types of shore are not completely distinct; that is, one type is integrated with another. For instance, rock may be surrounded by sand in some areas and in others surrounded by mud. The shore line is predominantly rocky in Maine and New Hampshire with a few sandy beaches appearing in the southern part of Maine and the northern part of New Hampshire. Since the rocky shore is the most common and the most prolific in its plant and animal life, we will focus on this type of shore.

The Rocky Shore

The rocky shore is typically divided into zones, sometimes referred to as regions or bands. Because of the varying environmental conditions which determine the zones, different plants and animals are found in each one. Some of these zones have been given names according to the most dominant organisms found in them. In this unit, we will commonly use littoral zone names. Littoral is an historical term meaning the upper part of the continental shelf. Scientists, teachers, and naturalists have over the years come to refer to these subdivisions of the rocky shore by a variety of names. There is no single set of names which is recognized as best. We have selected the following names and conventions for the regions or zones on the rock surface exposed between the tides.

- **Supralittoral Zone** is also known as the upper shore, splash, or spray zone. It is rarely covered by water to any appreciable depth but constantly receives salt water cover in the form of drops and splashes.

- **Littoral Zone** or black zone is often covered by water but not for long each day.

- **Midlittoral Zone** or middle shore is covered by water much of but not all of the time. Depending on local conditions it is the largest zone and has the most living space available for plant and animal life. This region of the shore is often subdivided into subzones or bands of living space for certain animals or plants which provide names for these bands. Sometimes these subzones are mixed and not in the order listed here:

  Subzones of the **Midlittoral Zone**:
  Barnacle Zone
  Rockweed Zone
  Irish Moss or Red Zone

- **Sublittoral Zone** which is variously called the laminarian zone and the scuba zone, is uncovered or waterless only on its extreme landward margin during periods of unusually low tides. This zone really includes the rest of the ocean but for practical purposes ends at 120 feet below the average level of the sea — the usual depth limit of scuba divers' activities.

Sometimes these zones can be seen distinctly along steep vertical cliffs as a series of horizontal bands or color zones. As the slope of the shore decreases, these bands begin to blend.

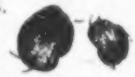
Your study of marine animals will take place basically in the intertidal region which is that part of the shore found between the highest and lowest of spring tides. This region includes the littoral and midlittoral zones. The supralittoral zone extends above this region and the sublittoral is found below it.

When you are looking for a shore to visit, the best are rocky shores which are gently inclined, have securely-based rocks with crevices and overhangs, and have a wide range of tidal pools. If the rocks are very round and smooth, they do not offer good areas of attachment for marine plants and animals. Rocky beaches which are well established with rockweeds offer the best hiding places for animals. However, you may have to look very carefully to find them.

Supralittoral Zone

The supralittoral zone, which is sometimes called the upper shore, includes a splash zone at the upper limit which occasionally gets wet from the sea spray. If the area is bare rock, orange or green lichens may grow here which are easily seen. If you use a hand lens, you will discover that a lichen is made up of two microscopic organisms which help one another, or have a symbiotic relationship. One is a green algae which provides food for the lichen while the other is a fungus which absorbs water

and provides a substrate. There are also different types of plants and shrubs which inhabit the part of the splash zone which has a modicum of soil. Mosses, beach peas, rugosa roses and glasswort are a few examples of these plants. Mostly land dwelling creatures are found in this area such as spiders, pill bugs and other isopods, terrestrial mites, and certain kinds of snails.



Littoral Zone

The next rocky shore zone is the littoral zone, also called the black zone. It is in this area that we find rocks covered with a very thin mat of microscopic blue-green algae, which, when concentrated or damp, make the rock appear black or dark green. Animals of this zone are marine species that can air breath or at least spend time out of the water, and are capable of maintaining a certain amount of moisture in and around their bodies. One such inhabitant is the rough periwinkle, *Littorina saxatilis*, which has distinct whorls in its shell and is light gray in color. Periwinkles have trap doors called opercula which when closed, trap moisture and reduce the drying out effects of the sun and extreme temperature. This enables periwinkles to travel upward into the supralittoral zone as well as down into the midlittoral zone. The limpet, commonly called a Chinaman's hat, is sometimes found in this zone. However, this animal preserves its moisture by using a strong muscular foot to adhere to the rocks. Both periwinkles and limpets obtain food by scraping blue and green algae from the rocks with file-like tongues called radulae. Limpets, like periwinkles, are also found in the next zone called the midlittoral zone or the middle shore.

Midlittoral Zone

In the upper part of the midlittoral zone, sometimes referred to as the **barnacle zone**, barnacles grow in such heavy concentration that they create a white uniform band. Another species of barnacle usually grows below this band in heavy brownish-yellow concentrations. The only time that you can clearly see part of the barnacle animal is at high tide when the shell opens and its six pairs of lacy legs come out to capture food and oxygen. During March and April, the larval forms of these animals are swimming in the sea to find a suitable area for growing. After attaching themselves to rocks, they change their body form to become adult barnacles. Although it is difficult to tell, barnacles are arthropods or crustaceans like lobsters and crabs. Because of where they live, however, barnacles need to be able to adapt to diverse weather conditions. Their conical shells and strong cement enable them to withstand tons of pressure from the waves. They also close their doors so securely that they can stay alive for long periods of time exposed to the extreme cold of winter or the baking hot sun of the summer.

The roving bandit of the high end of the midlittoral zone is the dogwhelk. This carnivorous and at times cannabalistic organism is about the size of a common periwinkle, but the shape is somewhat pointed. Turning this creature over on the foot side, a noticeable groove is found around the trap door region. This accommodates a tubular structure called a proboscis which is inserted through a tiny hole that it drills into barnacles or blue mussels. The dogwhelk, like the periwinkle, has a toothlike radula but it is better adapted for drilling holes than that of the periwinkle. It also releases a chemical enzyme to soften the shell of its prey which greatly aids the drilling. Many shells of dead whelks have these perfectly round holes drilled in them because they have been eaten by others of their own kind.

Besides having a pointed spire, a dogwhelk can be distinguished from a periwinkle by the shape of its operculum. The dogwhelk has an oval shaped operculum whereas that of the periwinkle is round. The color of the dogwhelk shell, which varies from all white to a pattern created by bands of brown and tan, seems to be determined by what the whelk eats. In late spring and summer you may discover the conical eggs of the whelk which are laid in clusters in rock crevices or on the bases of seaweed.

Occuring not so commonly in this barnacle subzone is a limpet. This gastropod or one-shelled, one footed mullusk is planktonic when young, and like the barnacle, assumes a conical shape when it becomes a settled adult. Its resemblance to the barnacle, however, stops at this point. The low contour of the limpet's shell and its flattened broad shape makes this animal very well adapted to a wave-washed zone. The limpet has a very large fleshy foot under the shell which is easily seen when the animal is attached to the wall of an aquarium. By using its foot, the limpet attaches itself to rocks and moves about when grazing on algae which is its primary food.

We also find small juvenile or adult blue mussels in dark crevices of the rocks. If the area is optimum for growth, mussels will grow in a distinct horizontal band. Mussels are related to other two-shelled organisms, called bivalves, although the foot is very much reduced. The common name of this animal comes from the fact that it is generally covered by deep violet to blue-black colored skin. This horny layer of protein often wears off when the animal dies exposing the light colored shell beneath. One peculiarity of the mussel is that it has byssal threads, resembling a thread-like beard, which it uses to attach itself to rock pilings and small stones. Since these protein fibers may be made or absorbed at will, mussels may move from one area to another. These byssal threads also provide shelter for small crustaceans and worms.

One kind of crustacean found among these threads, an amphipod called *Hyale mussoni*, is orange, has a body compressed on the sides, has small black eyes and usually hops when touched. Small round worms called hematodes, segmented worms called oligochaetes, and ribbon worms may also be found in the byssal threads.

Periwinkles may also be found in this part of the zone, sometimes growing so abundantly that they form a narrow band. Other forms of life may wash up into this region and some of those listed above may be completely absent dependent on the area, the exposure to wave action, and the slope of the beach.

As we move further down the midlittoral zone, we come to a part called the **rockweed zone**. This zone is dominated by two types of brown algae — bladder wrack or rockweed and knotted wrack. Rockweed is olive-green to dark brown, regularly branched, and has a tough leathery body. The branches may be somewhat spiraling and usually have paired air bladders with a central structure or mid-rib running down the length of the body. Reproductive structures may also be found at the tips of the plants from late spring through summer. Although rockweed, like all seaweeds, has no true roots, stems or leaves, it has a stem-like structure called a stipe and root-like structure used for attachment called a holdfast.

Intermingled with the bladder wrack, and appearing lower down in the rockweed zone is the knotted wrack. This seaweed, which is a perennial, is more stringy, very tough and is olive-green to yellow-brown in color. It, too, has small air sacs along the length of its branches which aid in flotation.However, in contrast to bladder wrack, knotted wrack has no mid-rib and the holdfast is very small.

Because the rockweed zone has much seaweed which retains moisture when the tide is out, many animals find protection here. Looking carefully under the seaweed, you may find green crabs, limpets, periwinkles, snails, beach hoppers, blue mussels, dogwhelks, scaleworms, barnacles, and occasionally sandworms. Hydroids, *Hydractinia echinata*, which may be found growing on seaweed, discarded periwinkle shells or moon-snail shells inhabited by hermit crabs, are also found in this zone. Some hydroids, which resemble plants more than animals, grow in branches with the ends of their polyps equipped with flower-like pink and red tentacles.

Another animal often found in this zone is the coiled tube worm or *Spirobis*. Although this animal superficially resembles a barnacle, if you examine it more closely you will discover that it has a white coiled shell made of calcium. When the tube worm is under water it relaxes and its tentacles may be seen. But, when disturbed or out of water, it closes off its tube with an airtight operculum. When tube worms appear on rockweed, they give it a white spotted appearance. Some may also be found on rocks, on the shells of snails, and on crabs. You will notice that some kinds of tube worms have coils which form in a left handed pattern, and others have coils that develop in a right-handed swirl. The individual shell pattern of a tube worm, along with its preference for habitat, determines what species each one belongs to. Tubeworms also have an interesting reproduction and larval development. They breed their young in an egg sac inside their shell which hatch out after a month or so. This usually occurs in June or July during the full moon, at which time the pink ciliated larval forms swim to the surface waters and search for adult populations. When they find a suitable habitat, they spin a calcium tube to live in within twenty-four hours.

The lowest level of the midlittoral zones is called the **red algae** or **Irish moss zone**. These algae are usually found on seashores exposed to the open ocean and offer a living environment for creatures not found in the other zones. Irish moss is a perennial seaweed which grows in dense colonies, on rocks seen at low tide or sometimes in twenty or more feet of water. The color of the plant may vary from bleached-out white to yellow-green or even a pinkish-green. Although its primary red pigment may be masked by other pigments to give it a slightly different hue, Irish moss is still considered a red algae. It is bushy, double-branched, has many blades which become very slender toward the holdfast, and is usually from three to six inches in length. This seaweed provides an ideal surface for the attachment of such things as oval windows, *Bryozoan*, and tube worms, *Sprirobis*. Around its holdfast you may find scale worms, round worms, and little amphipods as well as small blue or bearded mussels and periwinkles.

There are many other species of red algae growing in this zone. Coralline algae is one of these which encrusts rocks, giving them a reddish color. Another kind is *Porphyra*, a very thin membranous seaweed that resembles sea lettuce, *Ulva*, which grows in tidal pools higher up in the zone. *Porphyra*, which looks like purple tissue paper, is also found growing on coarser algae such as *Fucus*

Another red algae, called dulse, grows with blades extending up to twenty inches with an average of about eight inches. When dulse is wet, it feels slippery and has a very tough leathery texture. It may be found on other plants, rocks or even on mussels.

Further down the red algae zone, you may find other forms of plant and animal life in crevices, overhangs or isolated pools. One organism is the crumb-of-bread sponge, which filters sea water through its porous body to obtain plankton. Another animal you may discover is the green sea urchin which may be distinguished by its globular shape and its blunt spines. The urchin's mouth is located on its bottom side, and, by turning it over, you may observe how it chews. Its beak-like jaws are used to obtain food by scraping algae off rocks as it moves along on its tube feet. If you look in the upper shore zone you may find pieces of the sea urchin shell found here because they have been dropped by gulls who do so to feed on the inside flesh. You may find its whole skeleton called a test or part of its mouth supportive structure called Aristotle's lantern. By observing the shell and the structure of the urchin you will discover the symmetry of its design.

Starfish may also be found in this zone. These animals have tough skin, and like the sea urchins, have spines and tube feet. The common starfish is usually distinguished by its green or blackish-green color. The northern starfish also has five arms, but there are no definite lines on top of them. Also, its body is not as firm as the other starfish. The lavender starfish and the purple starfish are other names for this organism.

Other less commonly found starfish are the brittle star, sometimes called daisy star, and the blood star. The brittle star is, as its name implies, quite fragile and is recognized by its serpentine rays which may be seen around the rocks where it seeks protection. The blood star is crimson red and resembles the common starfish except that its tube feet are not as conspicuous and only occur in rows of two instead of in rows of four.

An interesting characteristic of starfish which you may observe in an aquarium is their strange feeding behavior. The starfish usually feeds in a humped-up fashion with its legs wrapped around a soft shell clam or a mussel. Using suction, it attaches itself firmly to the two shells with its tube feet and pulls the shell apart by exerting continual pressure. With the help of muscle relaxants that the starfish releases into the water, the mollusk tires and the shell is partially opened. The starfish then turns its stomach through its mouth and digests the soft body parts of his victim internally. All that is left after this feeding is an empty shell partly opened. Another interesting characteristic that may be noted if you observe starfish over a period of time is their ability to regenerate rays. Part of the central circle around the mouth must be present for this to occur.

Near or below the low tide mark in the midlittoral zone, one may find several types of sea anenomes. One of these is a flowering anenome whose body consists of a stem-like cylindrical body with petal-like tentacles. When the anenome is relaxed and covered by water, its tentacles extend, enabling it to capture minute life forms such as plankton. These tentacles have special stinging cells armed with a toxin which paralyzes the prey, although they are harmless to people. If the anenome is disturbed, it withdraws its tentacles into its body.

Another mollusk of this zone is the chiton. Like the limpet, it has a very muscular foot and feeds on microscopic vegetation. However, it is unmistakably different because it has a shell composed of eight overlapping plates.

Sublittoral Zone

The last rocky shore zone is called the sublittoral or laminarian zone. The upper limit of this area is uncovered only in extreme tidal conditions and the lower limit, which is sometimes called the scuba zone, is never uncovered. Although, for the most part, the flora and fauna of this zone are under water, you may observe several kinds of seaweed from the surface. One of these kelps resembles the fingers of a hand and another looks like a very long ribbon. Since the plants and animals living here are frequently subjected to the pounding of waves at the top of the zone, they must be well attached. The kelps have holdfasts which keep them in one place.

The alternative shore types where you may find animal and plant life are the sandy shore and the mudflat. A shingle or pebble beach offers very little security for either plant or animal life because of the grinding action of tumbling stones.

The Sandy Shore

Most of your study will probably take place in the rocky shore zones but a sandy shore may be adjacent to the rocky areas. The sandy shore offers no surface protection for its animal inhabitants. Therefore all permanent residents are adapted to digging in to retain their moisture and enable them to stay in one place during the pounding of the waves. The animals who live here include the common soft shell clam, the sandworm, and the hermit crab which is found further out in shallow water areas. Sand shrimp may also be on the surface around eel grass. Land plants found on a sandy shore such as beach grass, salt wort, and seaside goldenrod, are all important to stabilizing the sand and the dunes behind the beaches.

Strand lines are areas where the jetsam and dislodged seaweeds are deposited on the beach. You will note definite levels which indicate the level of highest spring tides and the most recent high tide. Examining this mass of debris will reveal sand hoppers, land insects, and other forms of animals.

The Muddy Shore

Another type of shore is the muddy shore. The mudflat or tidal flat found here is a fascinating realm to explore. Often thick carpets of green algae and eel grass grow on the surface if the flat is in a protected cove. These offer hiding places for sand shrimp, mummichogs, stickleback fish, and a variety of invertebrates. Organisms of this tidal region that are burrowers or infauna include ornateworms, sandworms, bloodworms, lugworms, and clams. Other animals you might find on a mudflat are crabs, periwinkles, mud snails, shrimp, and amphipods. Along the shore, you may discover plants such as succulent saltwort, sweet grasses, staghorn sumac, beach pea, strawberry, and raspberry.

Occasionally on both a sandy and muddy shore, quiet tide pools may be found which contain animals such as hermit crabs. If there are rocks in the pools, barnacles and seaweed may be growing on them. Organisms such as the tubeworms, hydroids, and amphipods may colonize in and around the holdfasts of the seaweed and on the surface of the blades.

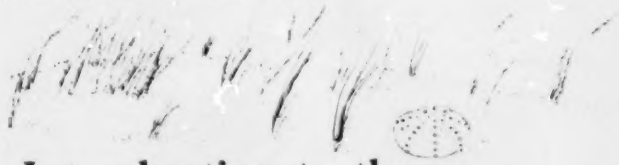
The Shingle Beach

Shingle beaches, which are made up of pebbles and rounded stones, are generally steep and exposed to intensive wave action. This is the most unsuitable type of shore to visit because the rolling stones do not allow much macroscopic life to gather on the surface. These beaches are interesting, however, from a geological standpoint. They are made up of many kinds of rocks which have been reworked by high energy waves through millions of years. They are also exciting places for listening. In addition to the sounds that can be heard as the sea washes through the cobbles, students may put their ears to the upper beach and hear thunderous sounds vibrating through the ground.

A Closing Note on Rocky Shore Zones

All the zones and bands within zones are highly variable and occasionally even absent, depending on local conditions. How much of a zone will be present on a rocky shore will depend on many factors, one of which is the angle the rock makes with the sea. The extremes of this range from a perpendicular cliff to a very gentle rise of less than five degrees. In the former condition where steep rocks are present, zones and bands or subzones are likely to be highly distinct and relatively narrow. With a small slope angle, some zones will appear very long while others may be missing or mixed with others.

Marine animals and plants have not read this unit so they may behave differently than we have described them. Zones and their names are a general guide to what you will find under typical conditions. In no case should students be caused to memorize zone names or taught that such names convey an invariable condition of major importance. What is important are the highly specialized adaptions of marine organisms to the places they live. This is a phenomenon to be explored, examined and admired in person, from books, film, and from the stories of people who frequent the beach, the shore, the strand or the littoral region — choose names with which you are comfortable — and ENJOY!



Introduction to the Animal Classification of Marine Invertebrates

Biologists have historically grouped organisms. The binomial nomenclature system was originally devised by Swedish botanist Linnaeus. This classification system is organized on the basis of common characteristics — structure, life cycle, reproduction, even blood chemistry. The groupings are hierarchical, occasionally arbitrary, and in many cases accompanied by controversies. Today's scholars will recognize major differences in the correct placement of an organism in even the largest groupings.

In order of complexity and in terms of numbers, the scientific scheme proceeds from kingdom to phylum to order to class to family to genus to species with occasional subsections of each. The classification system helps scientists to understand more about the form and function of living things and also to learn about evolution.

The Latin binomial provides a standard language for use around the world. The first word is the genus name representing a grouping of similar species. The second word is the species name, representing organisms so much alike in structure that reproduction produces fertile offspring.

In the pocket on the back cover of this unit, you will find some sheets which describe the common animals of the intertidal zone of northern New England — that is north of Cape Cod. We have included these as separate sheets realizing that in teaching the classification of marine invertebrates, you may wish to duplicate the charts to be used by your students. Because of a space limitation, we have selected those invertebrates, or animals without backbones, that you will find most commonly in intertidal zones you visit.

Establishing a Saltwater Aquarium

Objectives: ***To create an indoor environment for observation and study***

To increase students' powers of observation through special aquarium-related activities in science, math, language arts, and art

Materials:
- Tank
- Sand
- Filter
- Aerator
- Seawater
- Pump
- Hydrometer
- Other equipment optional

Timing:
The amount of time is variable depending upon how much of the activity is shared with students. You will need time for a collecting trip to the shore. You will need twenty four hours after the aquarium is set up before introducing specimens. The lifetime of the tank will vary according to your cooling methods.

Procedure:
Successfully establishing a saltwater aquarium in your classroom can be difficult and a little tricky, but it can also be very rewarding and a powerful teaching tool. Prepare your tank before you collect your specimens. Remember to allow a day for the tank to filter out the suspended sand and detritus that will be suspended in the water due to the setup activities.

First, buy, borrow or make a ten to fifteen gallon tank. This should be either glass or plastic, as seawater will rust the stainless steel part of a metal-braced tank or corrode its aquarium cement. Also make sure that all of the equipment in your tank is plastic, since many metals are toxic to marine invertebrates. A subsand filter tends to be the most efficient, but the ordinary box-type filter is also effective. Sufficient aeration is very important and is crucial to the use of your subsand filter.

To begin setting up your tank, first wash it well. Then place your subsand filter and air pipes in the bottom. Above this, layer pebbles and then sand. Next, fill the tank with seawater. Allow the filter system to thoroughly clear the water before adding your specimens. Natural seawater is advisable, rather than trying to mix artificial seawater.

When your system is set, you are ready to begin collecting your specimens. Remember to always make sure that you have permission to collect at your site. Decide what specimens you would like to have in your aquarium before you collect. When you collect, take only what you need and make sure you have provided for their comfort en route. Use plastic containers to carry your animals. Do not try to transport glass or metal containers while you are on the rocky shore. Small specimens should be collected and placed in plastic jars containing seawater. Overcrowding can result in the loss of all of your collection. A few live organisms per gallon of seawater is about right. In transporting the collections to their new home site, they must be kept cool. If you are traveling for any distance, place your containers in a styrofoam cooler with ice in between and fresh seaweed on top. Once back, allow the specimens time to become accustomed to their new surroundings by floating them in their containers in your aquarium overnight to allow water temperatures to equalize. The water in your aquarium may not look substantially different from the water your animals have been transported in, but to your new charges direct transfer to their new aquarium could be a shocking experience.

The aquarium may be kept cold by keeping it in a window area in the late fall through early spring months. Ice cubes placed in plastic bags and floated in the water can cool the aquarium inexpensively for short periods. Aqua-chillers are complete units that can cool a series of aquariums or very large ones. These are quite expensive but maybe your students may want to raise funds through a project. The key to success in keeping the organisms alive is to keep the water cold (about 40-50°F, 4-10°C).

To maintain your aquarium, you'll have to keep the salinity of the tank stable. When you first fill the aquarium, mark the water level with a piece of tape on the outside of the tank. The density of the water in the composed aquarium is important and can be checked with a hydrometer — available at a pet store. It should show a reading of 1.025 when natural seawater is filling the aquarium. As water evaporates and the salt concentration rises, pure distilled water should be added to the original water level mark. Any salt accumulating on the edge of the glass should be scraped off the sides and returned to the tank.

To maintain your animals, feed them as follows:

The starfish and clams can be fed with frozen clams. Turtle food and fish food may be added to the water to provide nourishment for mussels and small fish. For a while you may try an experiment

of adding a few extra mussels and not feeding the animals frozen food. In this more natural situation, crabs and starfish will find their own dinners. You and your students will have the opportunity to watch crabs and starfish opening the mussels. The small fish will "clean up" after the crabs are finished.

There are a few simple steps to remember for a successful aquarium:

1. Use natural seawater and maintain a constant water level.
2. **Keep the water temperature low.** If you need to reduce the temperature in your tank, float ice cubes in plastic bags or containers. Never add ice cubes directly to the water. Also, avoid rapid temperature changes.
3. Keep the water well aerated.
4. Don't overcrowd your aquarium.
5. Find out which animals are voracious predators. You may want to isolate these.
6. Feed your animals regularly and remove all uneaten food or dead animals to prevent fouling.
7. To avoid excess evaporation, keep the aquarium covered.
8. Keep the aquarium out of direct sunlight.

Specimens can be obtained from a marine supply house, but it is less expensive and more interesting to make your own collections. You can expect to find mollusks, crabs of various species, starfish, small marine fish, snails, barnacles, anemones and urchins, to name a few. Around a jetty or a rocky beach at low tide is the best place to look and collect. Collect various types of seaweed to enhance the attractiveness of the aquarium. You probably won't need any supplemental lighting unless you want to support several species of the green algae. The predominant red and brown seaweed do fine with regular fluorescent or incandescent light from your ordinary lighting.

Science Activities To Be Used With Your Saltwater Aquarium

1. What are the requirements of the plants selected? Determine predator-prey relationships of the animals selected for the aquarium. How do these organisms fit into the food web?
   a. Make a chart illustrating the role the animals and plants in your aquarium play in the food web.
2. Stop feeding the animals frozen food and stock the aquarium with a large supply of mussels. Observe results.
3. Do library research on the effect a variation of the salt content of the aquarium would have on the aquarium's tenants.

Language Activities:

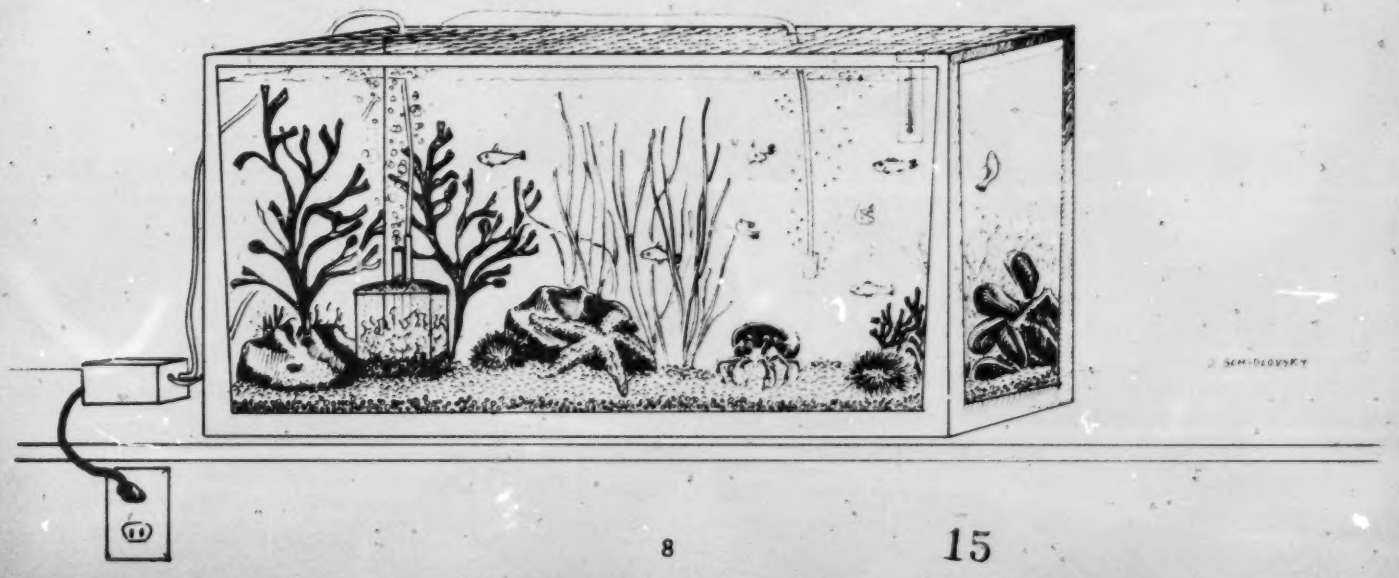
Have each student keep a journal of daily observations of the plant or animal of his choice. The journal may be picture and script, or just script.

Math Activities:

1. Record, chart and graph the life span of the different animals in the aquarium.
2. Record, chart and graph the growth of any animals or plants which can be measured.
3. Measure the water temperature daily. Graph the temperatures over time.
4. Record periods of greater or lesser animal activity. Graph in relation to times of day, periods of day, or months of years.
5. In liters, determine the capacity of your aquarium.

Art Activity:

Illustrate the appearance of the aquarium at different times of the day, specifically the effects of sunlight and shadows.



Many fine guides and teacher resources exist on this subject for your further exploration. These are three of the best:

- ***Small Oceans: 4-H Leaders Guide to the Art of Setting Up, Maintaining and Observing Sealife in a Marine Aquarium.*** Written by Barbara S. Waters and published by the Cooperative Extension Service, University of Massachusetts (Bulletin Distribution Center, Cottage A, Thatcher Way, University of Massachusetts, Amherst 01003). This is a very fine and well-researched guide.
- Bower, Carol E. ***Keeping a Marine Aquarium: A Guide for Teachers.*** The Children's Museum of Hartford, Connecticut. 1975. Well-organized and well-written.
- King, John M. and Kelley, William E. ***Marine Aquariums: Principles and Practices.*** Aquarium Systems, Inc., an excellent 25-page booklet — theoretical and practical.

Our Seashore Life

Objective: ***To identify common inhabitants of the northern New England seashore***

Materials:
- Classroom copies of "Our Seashore Life" worksheet found in the pocket of this guide.
- Field guides, books on seashore life

Timing:
Part of one class

Procedure:
This outline drawing of seashore organisms placed in the tidal zone where they most commonly occur could be used in a variety of ways. It could serve as an introduction to your unit on the shore by having students check the accuracy of their answers using resources such as field guides, study prints, and reference books. It could be used again at the end of your unit as a post-test. The worksheet could introduce a class period during which students would work in small groups identifying and researching the organisms and collectively developing brief reports on each one. It could also serve as a followup activity to a field trip to check recall of information.

We appreciate permission from the Massachusetts Audubon Society to adapt this drawing from one they originally developed called "Our Seashore Life."

Pressing Seaweeds

Objective: ***To learn techniques for preserving dried sea plants.***

Materials:
- Plant presses (can be homemade)
- 2 pieces 8½" x 11" unglazed white paper per student
- Freshly collected sea weeds from the midlittoral zone

Timing:
This activity requires a single class period to get the process started and then you need to wait for several days to several weeks for the result. Timing depends on how much equipment you have available. The activity can be started in the field, or if a field trip is not feasible, students may press teacher-collected material.

Procedure:
Freshly collected sea weeds, preferably wrack and rockweeds, are separated into small pieces for pressing. Groups of 3 or 4 students may be assigned to a press which they will load and maintain. Plant presses may be made as a class project. (See Figure 5 below.) A convenient size for a plant press is 10" x 14" which is small enough to carry in the field and uses regular size paper.

Each student should select a palm-of-the-hand size piece of wrack weed and rockweed to press. Before the students begin pressing, each should write his/her name on the bottom edge of the unglazed mounting paper in pencil. Pen will run and discolor the resulting press.

Actual pressing is accomplished as follows:

1. Place mounting paper in the bottom of a shallow pan such as a large glass baking dish. Metal dishes or pans are all right but may get rusty. Add about one inch depth of water, preferably sea water, and finally the sea weed piece. Arrange the plant material attractively and carefully to show all parts. Final arrangement can be accomplished with a small paint brush, tooth pick, or pencil point. Encourage careful arrangement. (Figure 1)
2. This is the tricky step. Carefully slide the paper and plant, "short end first," out of the pan. If this is done *slowly* the plant will retain its position. (Figure 2)
3. Place plant-on-paper onto a stack of newspaper for several hours up to a day to remove excess water. Be careful not to allow the plant to begin to dry out, however. (Figure 3)
4. Teams of 3-4 students may now load presses. Each press may contain 6-8 plant pressings. Start on the bottom with a thick pad of newspaper. Then add a sheet of blotter paper, corrigated box board or poster board. The first plant pressing goes next, plant side up, with a covering of nylon stocking material or waxed paper (nylon is better). The layer above the nylon is another pad of newspaper. Now the

process of stacking can be repeated. Finish off each press at the top with a thick pad of newspaper. The limit on the contents of each press is the length of the screws used to tighten it. (Figure 4)

5. Newspapers should be changed every day or so to hasten drying. Care must be exercised to avoid dislodging the plant while drying. As plants become dry they also become brittle, so care is required to avoid bending dry of semi-dry pressings. When drying is complete the results can be identified by consulting a field guide and placed into a class sea weed book or into a box style herbarium. Alternatively, the final pressings may be embellished with shells or other materials collected on a teacher or student field trip.

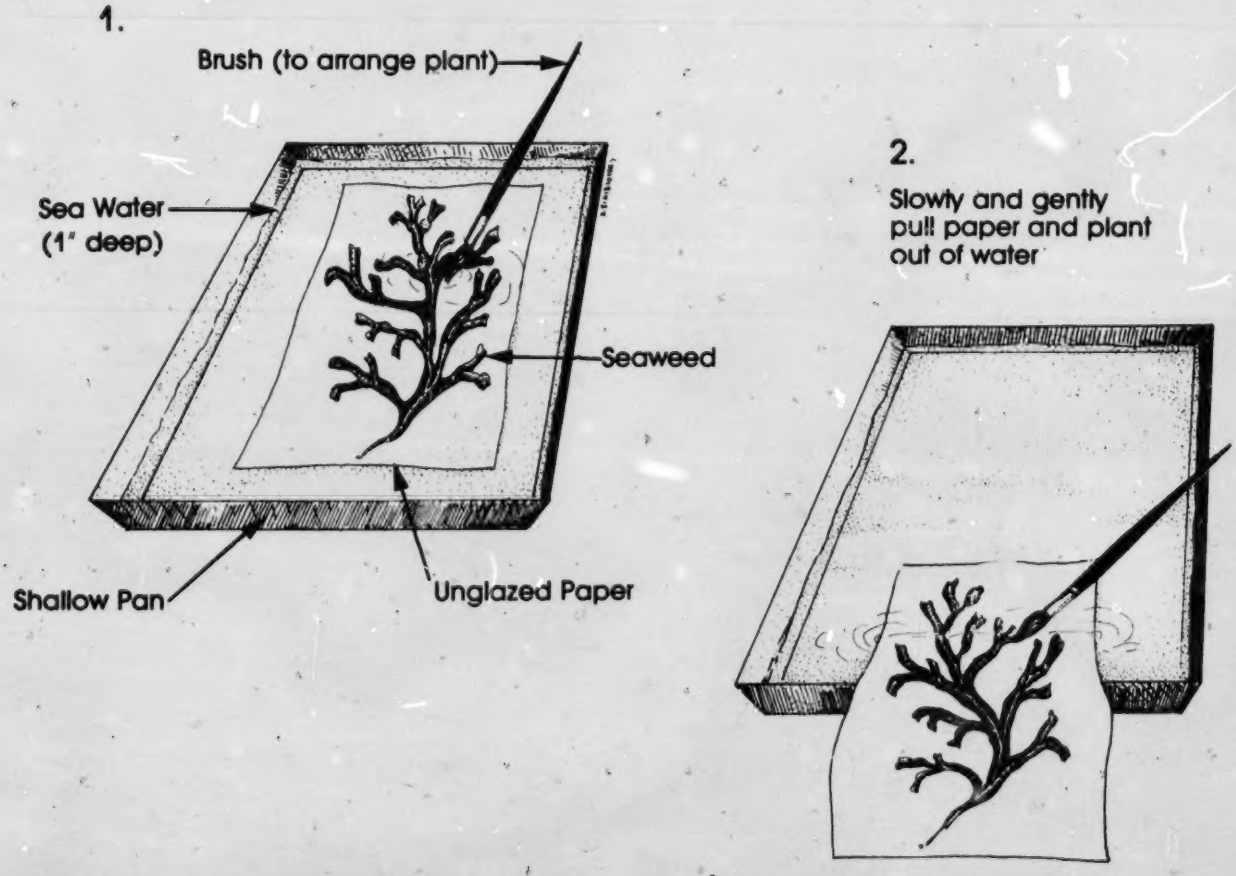
Another idea is to use a combination of dried animal hard parts and dry sea weeds to make a large natural mural of the rocky beach field site.

A Note on Equipment

This activity requires a great deal of clean old newspapers. Newspaper collecting should be planned well in advance. While unglazed paper from school supplies is adequate, art paper produces a finer backing for pressings that are to be displayed or kept in a herbarium. Half inch thick plywood or peg board is good for the top and bottom plates with long 1/4 inch diameter carriage bolts and wing nuts to hold the tension. Many holes are recommended to provide for more water escape. However, the process will occur with no holes at all. If you use peg board, no more holes will be needed. A more primitive apparatus can be made by using ends of boards for the top and bottom plates with bricks piled on them to provide pressure. A small easily transported press is preferable, however, because it has many field uses. Plan on 8 to 10 presses for a class of 30 students.

Plant presses and herbarium mounting paper may also be purchased from major biological supply houses such as Carolina Biological Supply Company, Connecticut Valley Biological Supply Company, Inc., or Turtox/Cambosco.

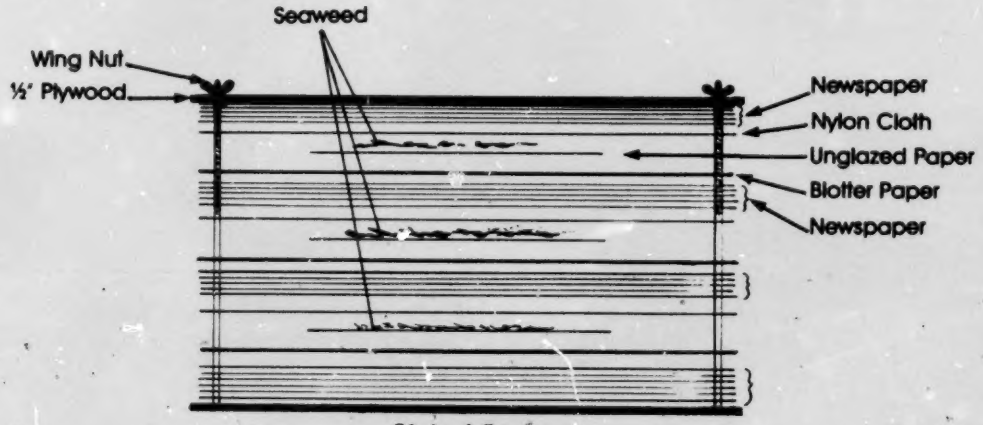
Seaweed Pressing Process



3.

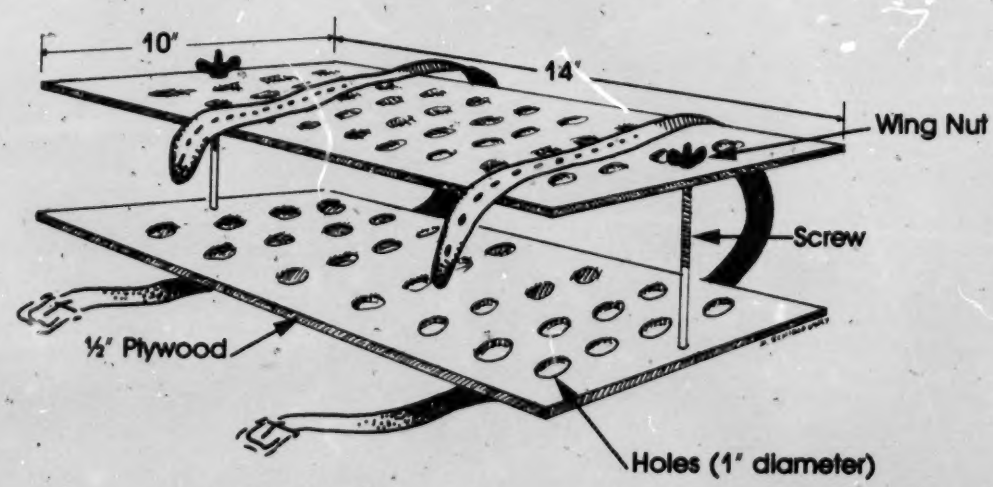
Newspaper Stack (used as a blotter)

4.



Side View

5. Plant Press



A Bulletin Board Field Trip

Objectives: ***To place zones in proper order from high to low water***
To explain the labeling of each zone
To identify at least three inhabitants of each zone
To explain why each organism inhabits its zone
To describe adaptations which enable the organism to survive in its zone

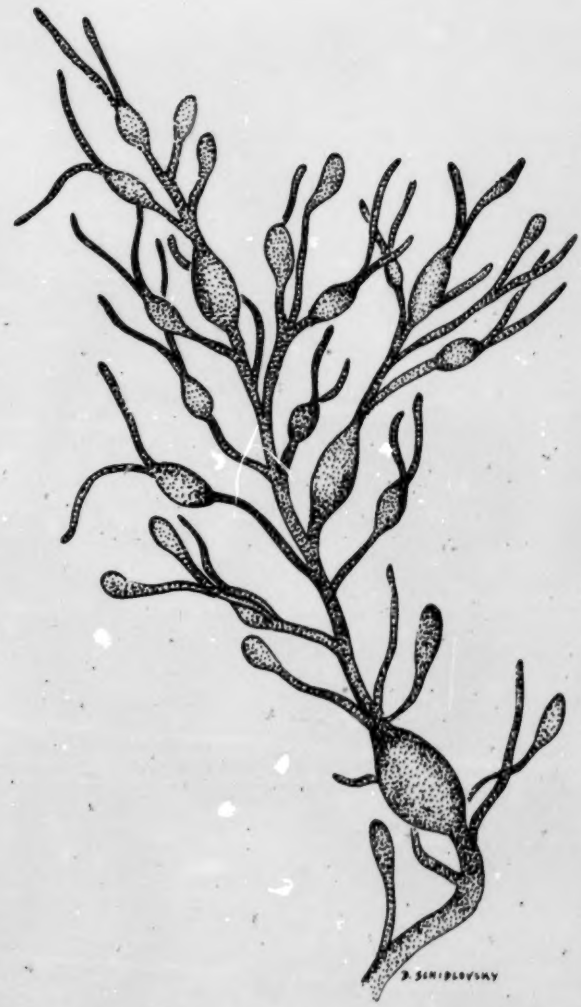
Materials:
- A large bulletin board
- Coloring materials
- Tape or other fastening
- Collected and preserved plant and animal material
- Other optional materials: filmstrips, reference works, slides of organisms

Timing:
2-3 class periods

Procedure:
Field trips to the shore are impossible for many schools due to distance or financial constraint. The opportunity exists, however for you to draw upon resources to substitute for first-hand experiences. This activity is designed to be used subsequent to other classroom activities such as filmstrips, films, labwork with shellfish, or teacher lessons. It will serve to draw together information learned in your unit and help you bring the seashore home to the classroom.

Students should be grouped into teams of two or three. Each team will be given one organism for each member; these should be handled, studied, and thoroughly researched. Up to two class periods should be allowed to complete written reports including detailed drawings of each organism. Students successfully completing their reports first could begin to show the zones by different colors on the bulletin board using colored paper or whatever material you choose. Oral presentation of each report must justify placement of the organism or a drawing of it in the zone it inhabits. If unchallenged the students may place their creature in its zone; if challenged, they must provide further evidence.

The result of this activity will be a large collage of accurately placed seashore life by zones. The procedure allows for you to work with the teams in questioning and demonstrating the use of reference works. The presentation of works provides a perfect opportunity to teach specific scientific information and the concept of adaptation.



19

Field Activities

Pre-Trip Planning

Objective: ***To actively involve students in the planning process of the field trip, thus increasing their motivation and preparedness***

Site:
The activity is included in this section because of its field trip nature, but it is actually conducted at school.

Timing:
One or two class periods as a group plus several hours of teacher planning

Procedure:
This section is written with the teacher in mind who has not arranged many field trips. Those of you who are old hands may find some ideas here to enrich your trips in these days of expensive fuel and tight school budgets.

We encourage you to share the responsibility of planning the trip with your classes as much as is feasible. This will vary according to your situation; obviously, it would be difficult to have your five classes involved in site selections and come to five different conclusions. Nonetheless, their input will help you, will prepare them, and will build a good sense of community. We will include student involvement suggestions only at specific places in the outline which follows; use your own style to involve youngsters at others.

A. Site Selection

1. Consider the alternatives. The "Field Sites" listed in this unit will be helpful if you do not have a particular destination in mind. If you'd like to combine your seashore trip with another stop, consult the "Aquaria, Museums, and Memorials" section, also.

2. Consider additional resources. In the "Resource Persons" section of this unit, you'll find listings of naturalists, cooperative extension agents, local people and others who can make suggestions, lead trips, and provide materials. It could be a student activity to initiate correspondence with some of these resources.

3. Beware of restrictions. Check to see if there are restrictions such as permission from private landowners, park officials, or environmental organizations on your visit. Read carefully *A Note on the Safe Collecting of Marine Organisms* included in this activity.

4. Assess your needs. Is there sufficient room for parking? Are bathroom facilities available en route or on site? Plan your day well to allow sufficient time at the shore.

5. Visit the shore in advance. Rehearse activities mentally for the time required. Take photographs to share in advance as slides. Check for potentially dangerous situations. Plan your class visit after consulting a tide chart for arrival at least one hour before low tide.

B. Advance Arrangement of Necessary Items

1. Coordinate vehicles. Are busses available all day? If you use cars, check minimum insurance coverage required by your school district. Day long policies are available for your uninsured and underinsured drivers.

2. Coordinate with those you'll leave behind. You know best how to make arrangements with other teachers, but suffice it to say that your trip may inconvenience them and greatly upset school schedules. Providing other teachers, your administrator, and the transportation supervisor with your arrival and departure times, your destination and a list of those going would be considerate.

3. Food planning. Students would love to help with this and there are many creative possibilities. High protein food and warm drink are best for cold outdoor activity. Concern yourself with the carry-in/carry-out philosophy as applied to paper, plastic, containers. Interest ebbs and accidents are more likely if students are hungry; perhaps the class could plan a healthy snack, like Gorp.

4. Materials needed. Good discussion could evolve from thinking about the special items students will need. It would be good preparation to review materials needed for specific learning activities. A basic homemade field kit for every two or three students would increase exploration. Discuss with them how to put one together — small pack, hand lens or magnifying lens, pencil, pad, collecting containers, kerchief, ruler, small mirror — whatever you decide.

C. Enlistment of Support

1. Secure field trip helpers. The organization, discipline and safety of your adventure depend on having enough adult assistance. A ratio of one adult to each five students is recommended. Parents, resource persons listed in this unit, and college students are good sources. Involve these volunteers as

much as possible and let them know what you expect. Give specific assignments, if appropriate. Encourage them "to get their feet wet"; their enthusiasm is a critical element.

2. Advise parents. Prepare a well-thought-out permission slip which states the objectives of the trip. Send home a checklist, perhaps prepared by students, covering warm clothes, food and beverage requirements, and foul weather gear. Be sure that you know of special medical needs such as allergic reactions to insect bites or severe reactions to poison ivy.

3. Let your community know. Tough as times are for field trips, it is important to share them and build community support. Why not have students write a news release for the local paper?

D. Preparation for Contingencies and Emergencies

1. Carry a first aid kit. Be certain you or one of your adult volunteers knows how to use it.

2. Inclement weather. Morale and safety can become concerns if you're not prepared. Discuss rain and wind in advance with the class. You may wish to center your investigations on adaptations to wet conditions. Have everyone bring clothes for cold and wet — just in case.

E. Your Attitude

1. Think of everything. Is it hunting season? Do your drivers need maps. Should you ban glass containers for collecting and for beverages? Do you need to carry some extra water? Do you want to take advantage of travelling time for an educational game? Your investment in careful planning will return a more enjoyable trip.

2. Don't feel you need to be a marine biologist or to lead a great seashore adventure. The attitude of mutual exploration with your students is *always* best, regardless of your knowledge.

3. Make it fun!

A NOTE ON SAFE COLLECTING OF MARINE ORGANISMS:

If you plan to collect specimens, it is always a good idea to check first by telephone with the Marine Patrol Officer of the Department of Marine Resources who is responsible for the town where your field trip will take place. There may be a local shellfish ordinance with which you must comply, a ban on some species due to Red Tide, or the area may be closed due to pollution of other types.

If the growth conditions of light, temperature, nutrient level, and salinity are in certain proportions, there may be a bloom of Red Tide. This occurs when the dominant phytoplankton species which multiplies rapidly under these ideal growth conditions is *Gonyaulax Tamarensis*. These phytoplankton produce chemical substances within their cells that are toxic to animals. Filter feeders such as clams, mussels, and oysters concentrate the toxin in their systems. Whelks, snails, and others that eat the filter feeders also become toxic. When a person eats these creatures, he or she may suffer from paralytic shellfish poisoning (PSP) which can result in illness and death. Fish, crabs, and lobsters contact this phytoplankton only indirectly, do not concentrate the toxin, and are safe to eat.

It is illegal to collect lobsters in any stage of development — larval through adult. Other marine organisms may be collected without a license when collected in small quantities. It is enormously important, if you feel it is necessary to collect, that you stress conservation and make plans for effective, humane transportation of the living things back to school.

Beach Profiling

Objective: ***To establish zones on a rocky shore based on animal and plant distributions found there.***

Field Site:
Rocky shore or beach with a fairly low slope making it safe to walk to the water line.

Materials:
- Large piece of paper on cardboard backing or on an easel
- Colored magic markers for teacher use
- Three rolls of inexpensive string
- One line level
- A waterproof collecting container
- A hand lens for each buddy pair
- A pole three meters long

Timing:
This activity will require about one hour and is best done during slack low tide, which is the period of about one half hour before low tide and a half hour after. This time period would give maximum exposure of the intertidal region. Consult a tide chart or a local newspaper for the time of low tide on the date you plan your trip. If you cannot plan your trip for a low tide, then it is safer to work as the tide goes out rather than the other way around.

Procedure:
Tell the class that they are going to become a scientific research team with the objective of determining if there are bands on the shore parallel to the water's edge made up by dominant species or inhabitants. Dominants may be plants or animals.

Students should then be told how to make a grid system of string as a guide for data collection. (Instructions follow this activity.)

When assignment of teams to bands is completed, demonstrate the procedure for finding dominant organisms by selection of the most prolific organism in a small portion of one band. Have the group suggest which plants and animals found in that portion are present in the largest numbers. Then ask each team to work their band for about twenty minutes selecting and obtaining a sample of each dominant organism and listing those most commonly found. Ask them not to remove organisms such as barnacles that live fastened to a substrate. This is to be a temporary collection placed into a little sea water in the bottom of their collection container.

While the teams hunt for dominants, establish your workplace at the center line in band 1 at sea's edge so you can check the safety of your class and at the same time, make a rough sketch of the bands on the large piece of paper as they appear from the top.

At the conclusion of the hunt, ask teams to label their collecting container by their band number and leave it at the lower edge of their band at the center line. Now ask the whole class to congregate at the center line of band 1. If you had different

teams working left and right sides of band 1, have them compare their findings and ask the class to decide which are the dominant organisms of band 1. When that is completed have the class compare band 1 with band 2 above it. If there is a great deal of similarity between bands 1 and 2, remove the string between the two bands. On the other hand, if the two bands appear different in dominants retain the line between the bands.

When lines are removed, combine the contents of the containers collected in all bands within the whole. For example, if the line between band 4 and 5 is removed, the contents of containers collected in bands 4 and 5 should be combined.

The final step of the process is to return to the water's edge and record the results of the combination of containers on your class diagram. Ask the class to name the bands which remain after string removal for the dominant organisms found in them. If you do not know the names of the organisms you may want the class to invent a descriptive name or retain samples of them for later identification.

Collection of large numbers of specimen organisms should be avoided. However, you may wish to collect a sample of each dominant for the final zones to take back to the classroom. Remember that marine plants and animals will soon start to decay and smell. It is recommended that you preserve them in formaldehyde, dry them in the sun for several days, or press the marine plants and retain samples of already dried hard parts of animals for displays.

You may also desire to take *small* samples of the different rock types at the field site and should, if at all possible, photograph or sketch the final result of your zone study.

Field notes taken by the class and specimens should be used in the classroom to rebuild a scale model or diagram of your findings incorporating specimens and rock samples if collected.

It would be good for you and the class to discuss your zones compared to the examples provided earlier in the teacher's background section. Remember, of course, the your findings may be more correct for your field site than the generalized picture presented there.

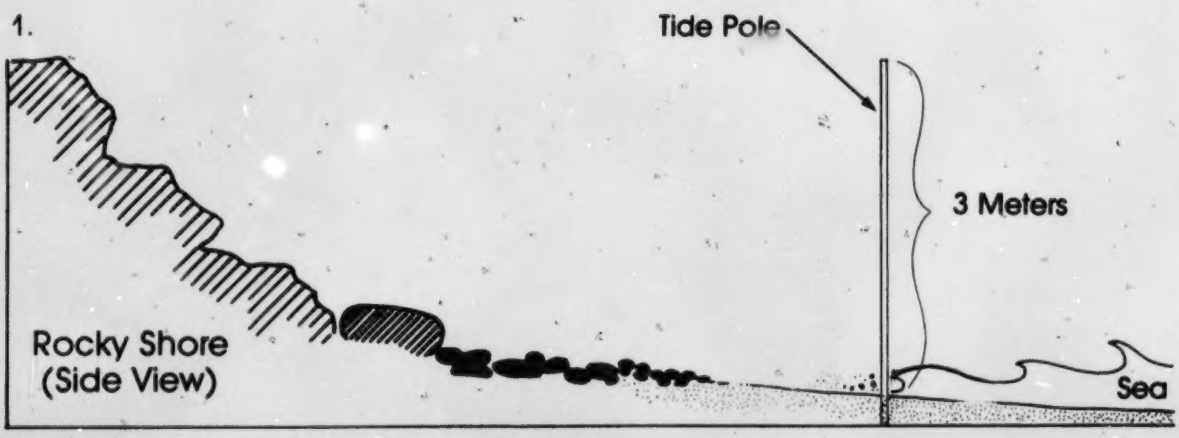
In the event that your class cannot actually take the field trip described in this activity, you may take it yourself and collect and dry or preserve specimens so they have a realistic experience perhaps augmented by slides that you take at the field site. Information collected at a particular location is much more useful for discussing zones than general information.

A Note on Equipment Preparation

String, poles, hand lenses and possibly a camera and specimen preserving container are relatively easy to find. You may not want to purchase a line level although they are relatively inexpensive. A line level can be made from a small test tube filled almost to the top with oil and capped with a cork or stopper. This line level can be taped on the string.

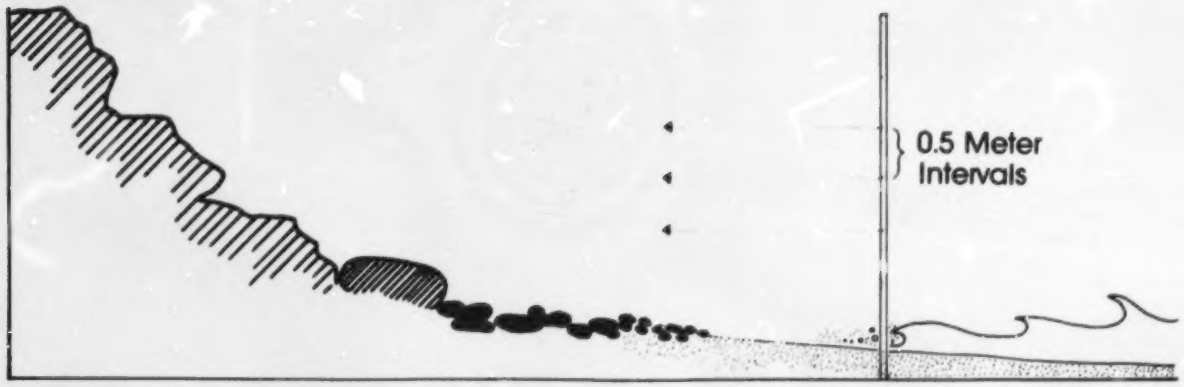
A collecting container can be made from gallon plastic milk bottles or similar containers. If liquid chemicals such as chlorox were the original contents of the container, it should be thoroughly washed before it is brought to school lest you poison your specimens.

How to Make a Grid System



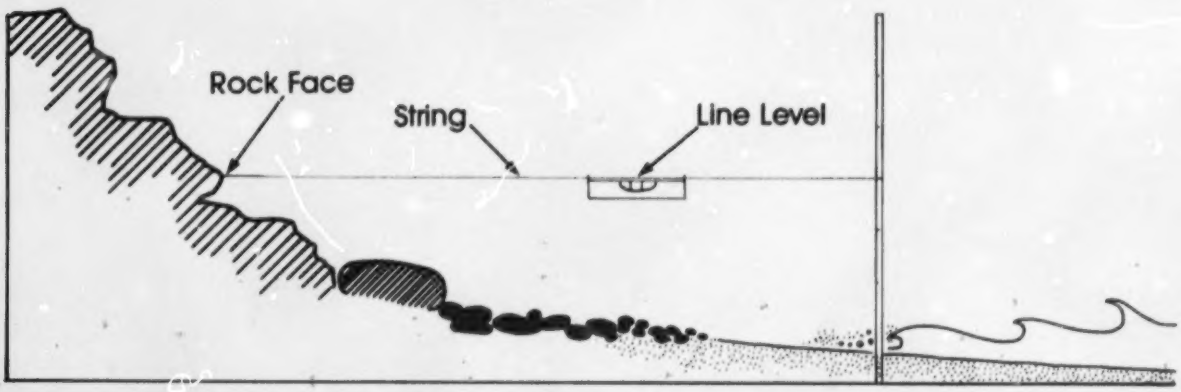
This grid is made by placing the three meter pole at the water's edge and anchoring it by pushing it into the bottom or propping it up with a pile of small rocks.

2.

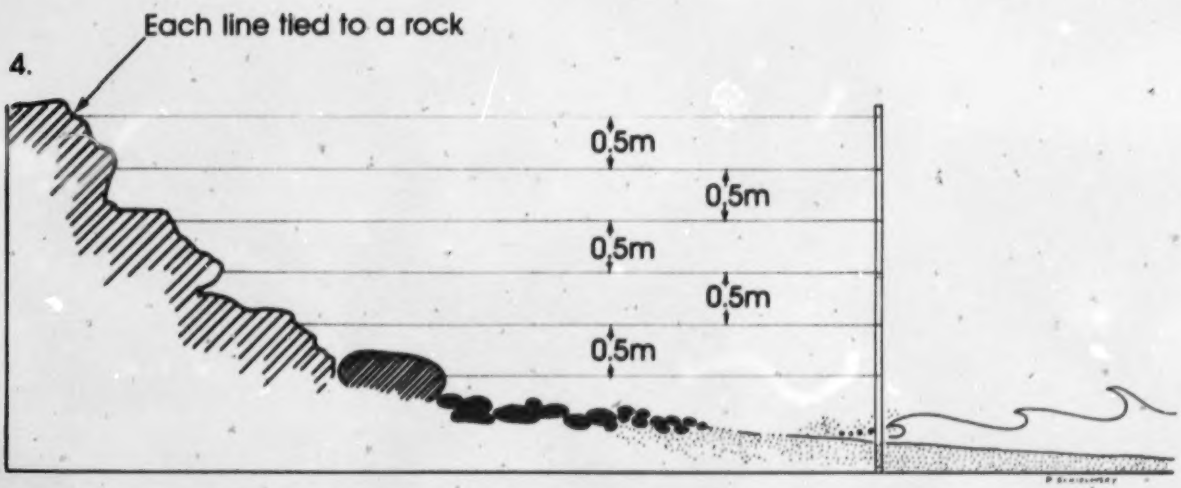


Lines of string are then attached to the pole at half meter intervals up from the water. As each line is attached, the line level is held to the line and the line is stretched straight into the land as close to perpendicular as possible to the shore line.

3.

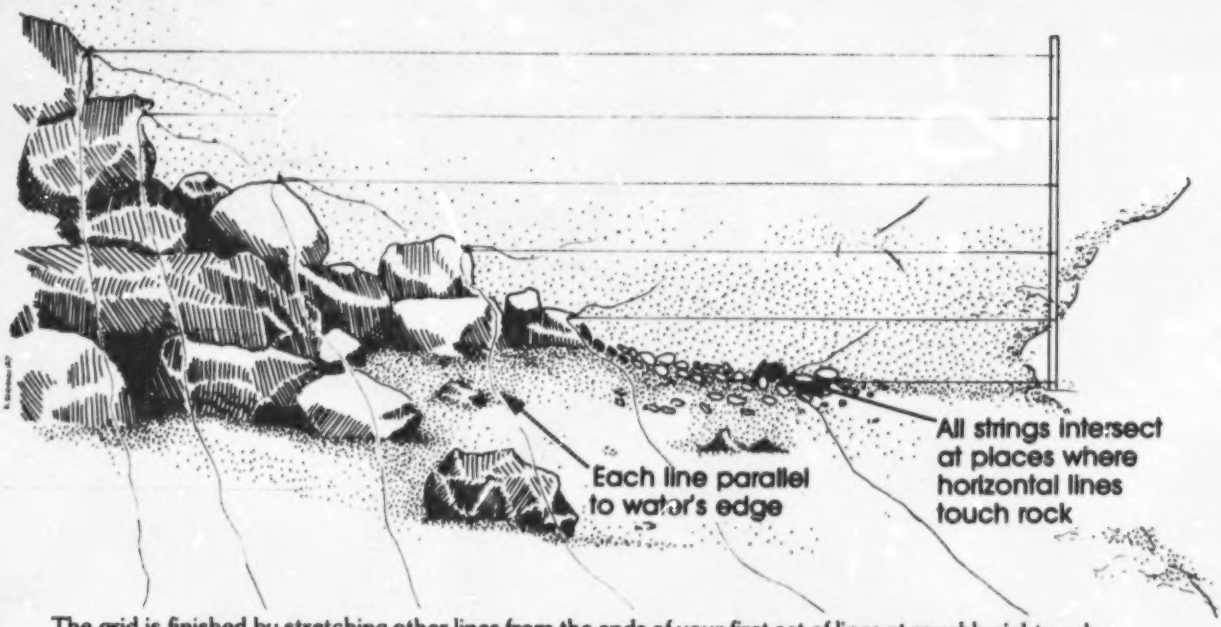


Unroll enough line to reach from the pole to the rock face keeping the line level.



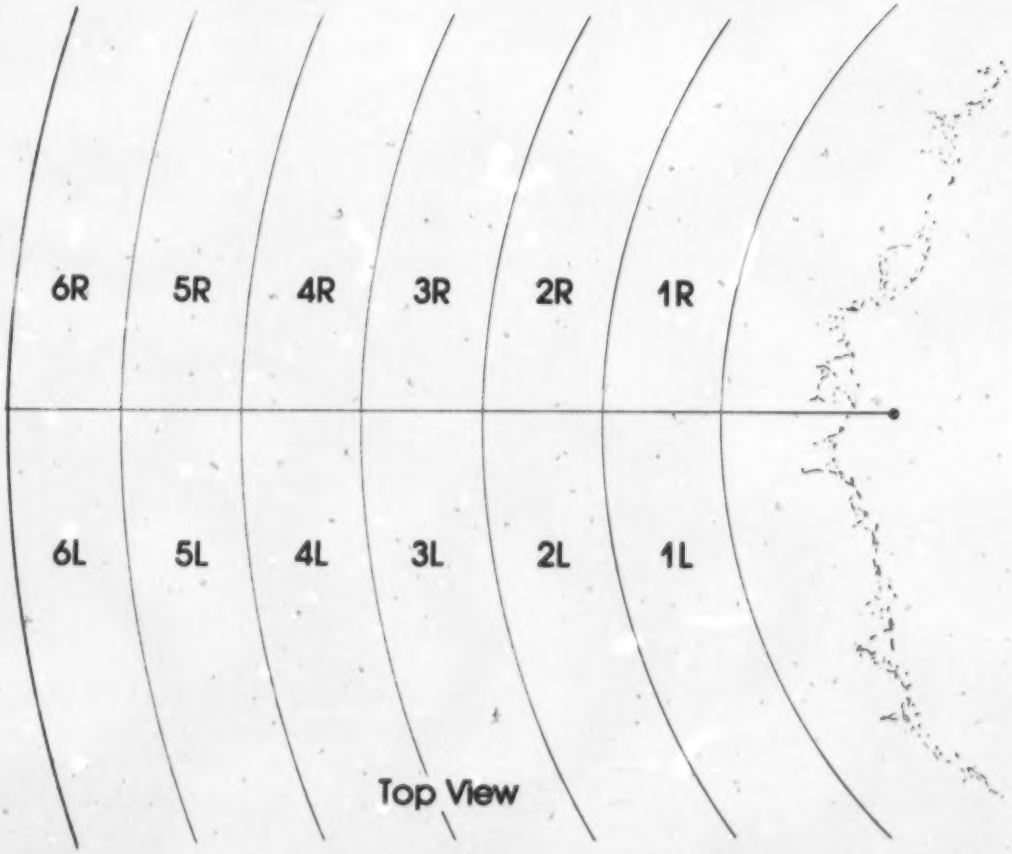
Tie the end of the string to a rock and leave it as level as possible. Now, attach the second line and so on. Student teams should be involved as string tiers, adjusters and tide pole watchers.

5.



The grid is finished by stretching other lines from the ends of your first set of lines at roughly right angles and out to about 30 meters on each side. Count the number of spaces between the lines as viewed from above. If you had a three meter pole and all lines from it touched segments of rock face which were higher up each time, you would have six bands along the beach representing that section of the beach which is 0.5 meters above the preceeding one.

6.



Assign buddy teams to bands with equal numbers of teams to each band. If your class is large enough you may assign a team or two to right and left halves of each band.

Exploring for Green Crabs

Objectives: ***To discover and observe one specific marine invertebrate closely and personally***

To describe the dynamic relationships of this specific marine invertebrate with other organisms and with the physical environment as characterized by its ecological niche, position in the food chain, physical space requirements, and specialized adaptations

To be able to record the major sructures for locomotion, respiration, food gathering, sensation and protection of one specific marine invertebrate

Field Site:
Seaweed covered rocks and tidepools; some work in the classroom

Materials:
- Crab-sized plastic containers (at least 15 cm across)
- Green crab drawing in pocket of this unit
- A ball of string
- One basic field kit for each group of five students (optional) which contains:
  30 centimeter ruler
  thermometer
  hand lens
  pencils
  pad
  small strainer
  watch with second hand

Timing:
Allow two to three hours of actual activity time. Variable preparation and followup time would be needed in the classroom, perhaps one class period before and three to eight class periods after.

Procedure:
This activity will help you and your students to focus on one aspect of the tidepool community. Discovery and observation will lead you to learning some basic facts about life as the green crab lives it. From there you can expand these basic ideas to general concepts about how one individual will function within a population and how that population may function with the total tidepool community.

Background:

Crabs, like other crustaceans such as lobsters, crayfish and barnacles, wear their skeletons on the outside. Unlike the lobster and crayfish, however, crabs carry their abdomens underneath their body. Crabs have five pairs of legs, their first pair being larger than the rest and bearing large pincers. The last of these walking legs are slightly flattened and used in swimming. If you watch crabs for any length of time you will notice that they prefer to move sideways and will use the backward-forward mode only when choosing a hiding place. Crabs are hunters and scavengers, often feeding on dead animals and plants. Many species of crabs are found throughout the world, some living in the sea, some living on land. Water dwelling crabs breathe by gills set in cavities on either side of their bodies. In land dwelling forms, these cavities are larger and gills are replaced by lungs.

No species of land crabs are found in New England, but four water species are common. In deep water offshore you will find the spider crab, *Hyas coarctatus*. The rock crab, *Cancer Irroratus* and Jonah Crab, *Cancer borealis* and two of the larger crabs are found in the intertidal zone near the low tide line. Higher up on the shore, where fluctuating tides leave the rocky shore exposed for longer periods of time you will find the little green crab, *Carcinus maenas*.

This green crab will likely be the first crab species that you will discover while exploring the rocky shore. *Carcinus maenas* is bluegreen in color, and hides beneath rocks and seaweeds during the day and prefers to actively feed at night. The front edge of its shell is rimmed with ten distinct teeth and tends to be more triangular in shape than the larger, reddish rock and Jonah crabs of deeper water. Though considered to be swimmers, green crabs lack the characteristic paddle shape of the last pair of walking legs. In the spring and early summer, females carry eggs on a broad, convex tail. Males, in contrast, have tails that are concave and narrow. Since shells don't expand the way animal skin does they must be shed periodically as the crab grows. During your exploration see if you can find any of these molts.

Before you go, you might have your students do some research on crab anatomies to see how they relate to insects and lobsters. Another suggestion is to have them read and report on the aspects of the green crab's life history.

At the shore, divide your students into exploration groups and let them try several of these exercises.

1. Find a green crab...and just get acquainted. Be friendly and sit quietly at the edge of a pool and watch for five minutes. Where do crabs hide?

B. Find a green crab...and learn about its anatomy.

1. Catch a crab carefully. Use a hand lens to study its eyes and shell. Is there anything living on it?
2. Identify if it's a male or female. Can you find any females with eggs. If you've found more than one, are the color of the eggs the same? Why?
3. Can you find any molts or newly molted crabs? Are newly molted crabs different from older crabs?
4. If you find a rock or Jonah crab, how do they differ from the green crab?

5. How are our bodies similar to the crab. How are we different?

C. Find a green crab...and learn about where it lives on the rocky shore.

1. Distribute your group along the shore from the high to low tide lines. Have each group mark off a four-sided area with roughly meter-long sides of rope.

2. Each exploration group should describe and record specifically the kinds of things they see in their quadrant. Take about five to ten minutes to do this.

3. Now have each team count the number of green crabs in their plot. Note the size and sex of each. Are they mainly male or female. What is their average size?

4. After gathering the data, compare each team's findings. Where did most of the green crabs live? Why are they green and their neighbors, the rock and Jonah crabs, red?

D. Find some green crabs...and see how they behave.

1. How fast can a crab move?

   a. Take some string and mark off a race course of any size. Some crabs may be uncooperative, or not too interested in moving far, so it might be a good idea to set up a small course.

   b. Start your crab at any point on the outer circle.

   c. Begin timing when the crab starts to move. Take care not to harm the crab.

   d. Note the time when he or she finally crosses the string again; this is the end point. Measure the distance he traveled by the time he or she took to run it (distance ÷ time = rate).

   Do this in metric units. Who runs faster? Males or females? Smaller or larger crabs. What is your running rate? How fast can you run crab-style?

2. How do crabs eat? What foods do they prefer? Place a crab in a clear container of sea water. Observe his mouth movements. Where is his mouth anyway? Is it built like ours? Feed him or her some food. Observe. Make a crab corral with your rope on the shore. Place three different kinds of possible crab foods in the corral. Release your crab. What happens. Which food does it prefer? Does it choose the same food all the time? If you face it away from the food, does this influence the food choice. Would it react differently if you had kept it from eating for several hours beforehand?

3. How about hiding places? If you were a green crab, where would you prefer to hide? Instead of food, give your crabs a choice of hiding in or under, a container, some rocks, some seaweed.

4. What happens when you put two crabs together? Will they act differently if both are male or female. How about when you add food?

Back in the classroom try some of these activities.

A. Talk about your data. Create a mural or collage illustrating your findings.

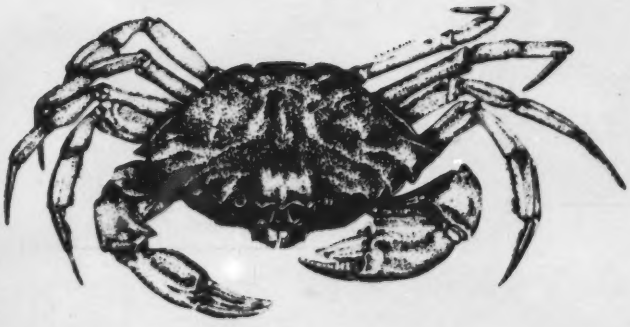
B. Talk about crab behavior. Teach about the relationships of this species to its environment. Prepare a lecture on crab physiology and life history.

C. Sponsor a "Let's be crabby" day in your school. Interview and tape a typical "crab" and find out what his day is really like. Make up and tape a new radio show, "Crab Wars." Sponsor an art show of sculptures, mobiles, sand paintings and kites with crabs as your theme.

D. Do some cooking and eating! Find out which crabs are sold commercially and what their life histories are like.

E. Research the crabs role in literature, mythology, and astronomy. What are crabs used as symbols for? How did the little green crab get his Latin name?

Unless you have adequate facilities to keep your crabs healthy en route and in the classroom, do the exercises involving the animals in the field. In either case, remind your students to be *gentle*, while picking up, handling and putting back their crabs. In the field, don't keep your crabs out of the water for too long and try to provide some shade while doing your experiments. Caution your students about proper handling so that both student and crab come away happy. The activities which do not involve live specimens could cover several periods depending upon student motivation.



Watching Critters

Objective: ***To improve abilities to observe and describe the animals of the midlittoral zone***

Site:
Beside a tidepool on a rocky shore or in the classroom beside an aquarium.

Materials:
- Styrofoam cups or small plastic food cartons
- Hand lenses
- Drawing paper
- A collection of poetic and fictional marine related adolescent-level books
- Several different field guides
- Notebooks
- Pencils

Timing:
Depending on student and teacher interest this activity can last from one class period to five.

Procedure:
To begin this activity, select one organism for group study. Pick it at random from the pool or aquarium mentally but leave it in place. Using a question-game procedure have the class guess what organism it is by using hints. Select hints carefully to reflect:

- Shape, including symmetry
- Color, including texture and color blends
- Shape, size and attachment of legs, feet or swimming parts
- Hard parts, covering, or exoskeleton
- Special sense organs including single or compound eyes, tentacles, antennae
- Presence of protective adaptations such as camouflage, spines, claws, teeth or other weapons

This initializing experience may be repeated by having students select other organisms. Four or five should be used before going further.

The second major part of this activity involves having each student choose a pet organism and making a log or picture essay of the appearance and behavior of their pet. Students should be encouraged to make at least six major, full page entries in their log.

You might choose log entry types from this list:

1. A realistic diagram or sketch showing top, bottom, end, and side views with exaggerated detail views of claws, spines, teeth, etc. Hand lenses and dissecting or binocular microscopes would be helpful to augment the naked eye observation.

2. A surrealistic or impressionistic view emphasizing what the organism feels like, how it spends its time, or what it "thinks" of the world around it.

3. A print on rice paper or cloth of the hard parts of the organism. This works especially well with

dried sand dollars and other flattened organisms. Put silk screen ink directly onto the object to be printed with a small paint brush and then gently rub the surface of the paper or cloth when placed over the object.

4. Animals that walk on feet can walk through ink and then on paper, leaving their preserved footprints. Use water soluble ink and clean your organism before returning it to its home.

5. Photography should be greatly encouraged. Black and white photographs which are greatly enlarged work wonders in bringing small parts into focus. A slide projector can be used as an enlarger or inexpensive equipment can be purchased.

6. A one page scientific essay describing a major function such as how the mouth works.

7. Fanciful writing can include a description of how the animal "feels" as it encounters another animal, the edge of the tide pool or aquarium, and so on.

9. Collages of natural and pictoral material can add the dimension of how the animals is used, e.g., crab meat salad and crab hard parts.

If students need more help or desire more depth in observation, you might consider the following observational extenders:

1. Take a dark piece of construction paper and cover the cup with the organism in it. Darken the room and shine a flashlight through a narrow slit in the paper. Is the organism attracted to light? Or is the response negative?

2. You might remove the animal to a larger container or tray of sea water. Students could measure the organism's rate of movement against a standard such as a meter stick. Students could also draw a motor pattern over a period of time, such as fifteen minutes. Simply have them trace the path of the organism on the paper.

3. Study the use of external body parts such as attachment of threads and shell closing procedures. Does the critter have a hinge ligament and muscle to help? Study the use of tentacles. Are they for moving, feeding, or detecting things in the water? Is there a difference in the use of the large claw and small claw in the crabs?

4. Observe preferences for hiding places. Provide objects such as small clay or plastic plantpots, stones, other non-metallic objects that are suitable habitats for them. Do they like dark areas? Does this behavior change during the day?

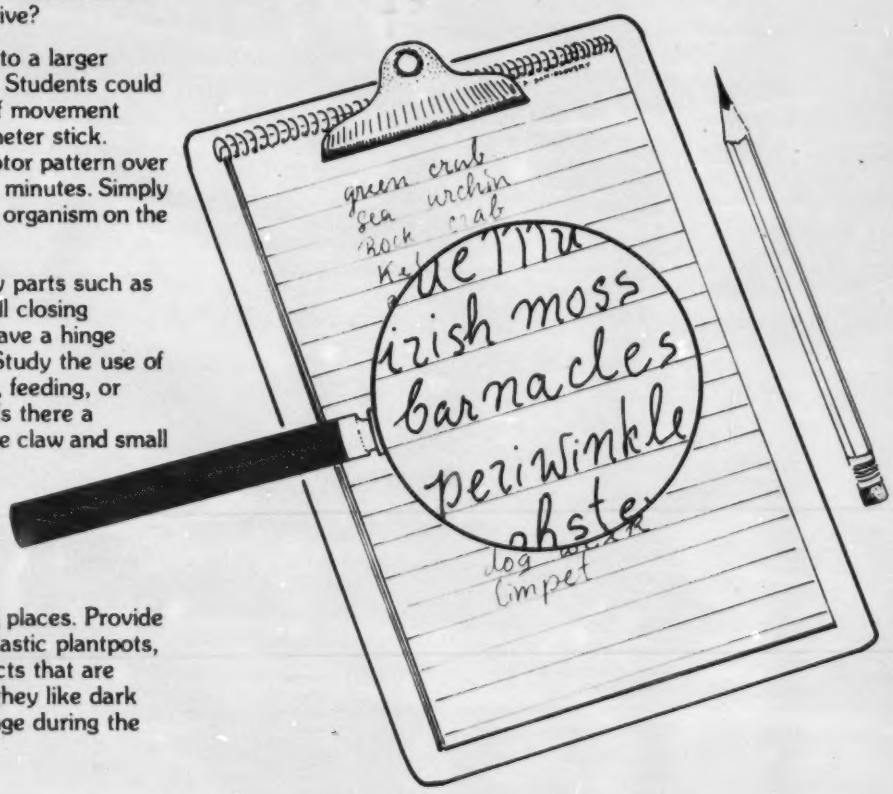
5. Consider the ability of the animal to learn to respond to feeding schedules. Attempt to keep a regular schedule. How do the organisms react when it's close to feeding time? Is there any difference in its behavior?

6. Study the preference for different bottom covers in the observing dish. Try placing the animal in two different containers, for one interval in a dark bottom dish, another in a light bottom. Do the animals move up the side of the container or do they prefer the bottom?

7. Observe behavior in the presence of another animal of the same or different species. Try setting up a tray of salt water and placing a number of different animals in the same tray. How do they react to one another individually? As a group? Students may see examples of predation, defense, aggression, social order, and so on.

If you do this activity in the classroom with organisms collected by the class or teacher, you will need to keep your critters alive and cool. One easy method is to use a large picnic cooler as an aquarium. Fill it with salt water and critters. Place several sealed plastic containers containing ice in the cooler. Avoid having fresh water mix with your salt water. When you reach home, attach a bubbler.

To follow up, you could invite other classes or the whole school to see the displays of log pages. Perhaps a classroom log could be made from each student's choices of his or her favorite work.



A Field Guide to Questions About Seashore Life

Objectives: ***To encourage the asking of good questions***
To generate interest in many aspects of seashore plants and animals
To learn reference skills

Field Site:
Preferably a seashore situation with as much diversity of environment as possible, rocky shore with sandy or muddy beach nearby, also classroom.

Materials:
- Classroom copies of "A Field Guide To Questions About Seashore Life" pages found in the pocket of this unit
- Pencils
- Cardboard or clipboards
- Hand lens, if possible
- A reference shelf of key resources for student research
- Dictionary
- Field Guides
- Encyclopedias
- Books about the shore

Timing:
At least one hour of actual activity time. Classroom followup time will vary from one to five class periods.

Procedure:
After reproducing and distributing a copy of the guide for each student, have them make, at home, a clipboard from cardboard or masonite to use in the field. Of course, they could use a ready-made one, but it is unnecessary to purchase one. In either case have them attach their pencil with a string. With these, and with a hand lens or magnifying glass (if possible) your students will be ready for an exciting in-depth exploration of plants and animals of the seashore.

The guide is designed to encourage active student involvement, stimulate questions after answers, and make possible further student questions. It may be used in many ways and we encourage you to be creative. A student might ask another question instead of answering one, for example.

We recommend you form diverse, small exploration teams which will work together on a small number of organisms. They could seek to locate, observe, and answer/ask questions about them. Depending upon the time available information could be shared and then a new exploration begun for a new set of organisms.

Back in the classroom, each organism could be reported on by the exploration team. They could ask their classmates questions and be asked questions by them. This could be followed up with research for further learning using your reference books.

A Note About Questions:

Questions are our stock-in-trade as teachers. We seem to ask and answer them all day long. The type and quality of our questions has a great deal to do with the nature of learning that takes place for our students.

We encourage you to ask hard questions but to use the answers as a process toward finding out all you can about the questions. Don't be afraid to ask questions to which you do not know the answer, or to which nobody knows the answer. If you set a tone of mutual exploration you and your students can learn a great deal from questions without already articulated answers.

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Teacher Resources

Organizational Resources

These organizations can help by providing a variety of materials and services; we encourage you to contact them for assistance.

New England Aquarium
Central Wharf, off Atlantic Avenue
Boston, Massachusetts 02110
Telephone: (617) 742-8830

The Aquarium provides superlative classroom materials, in addition to being a favorite destination for annual field trips. The philosophy of the Aquarium is "to make known the world of water" through education, research, and recreation. The ARK (Aquarium Resource Kit) is available for two dollars. Although it is designed for classes that will visit, it has much valuable information on adaption and coloration for any class. The Aquarium has a curriculum resource center which you may use by mail or in person.

United States Department of Interior, Fish & Wildlife Division
Refuge Headquarters, Parker River National Wildlife Refuge
Newburyport, Massachusetts 01905
Telephone: (617) 465-5753

The Refuge Headquarters provides educational packets, programs for children, and self-guiding nature trails at their site.

The Audubon Society of New Hampshire
Carol E. Smith, Education Director
3 Silk Farm Road
Concord, New Hampshire 03301
Telephone: (603) 224-9909

This organization is involved in the Odiorne Point Interpretive Center in Rye, which is a cooperative venture among the Audubon Society of New Hampshire, the University of New Hampshire Marine Program, and the New Hampshire Divison of Parks and Recreation. In addition, they have a library in Concord which includes children's books and reference materials on marine topics. They publish young people's bibliographies, one on "Seashores" and one on "The Open Sea," which are available for 25¢ each from the Society.

New Hampshire Department of Fish and Game
Education Division
Bridge Street
Concord, New Hampshire 03301
Telephone: (603) 271-3421

The department can provide print material for teachers.

New Hampshire Department of Resources and Economic Development
Judy Silverberg, Interpretive Specialist
Parks and Recreation Division
6 Louden Road
Concord, New Hampshire 03301
Telephone: (603) 271-3556

The Department offers a variety of educational services and resources. Write or call for details.

Office of Cooperative Ocean Programs
University of New Hampshire Marine Programs
Julia Steed Mawson, Marine Education Specialist
45 Pleasant Street
Portsmouth, New Hampshire 03801
Telephone: (603) 431-5344

Many fine services for teachers are available through the UNH Marine Program including marine resource workshops for educators, programs at Odiorne State Park, and consultation with teachers to assist in their programs. Materials are also available in the Marine Resource Center at Durham.

University of New Hampshire
Sharon Meeker, Marine Program Coordinator
Marine Program Building
Durham, New Hampshire 03824
Telephone: (603) 862-1889

Extensive special services include outreach programs in the schools, a speaker's bureau, and marine resource workshops.

Shoals Marine Lab
John Hieser, Director
Post Office Box 88
Portsmouth, New Hampshire 03801

The lab offers teachers workshops in marine science for educators.

SALT
Christensen Lane
Lower Village
Kennebunkport, Maine 04046
Telephone: (207) 968-3311

The educational, cultural, and literary purposes of SALT encompass publication of books and a highly-recommended journal, sponsoring a boatbuilding apprenticeship program, and finding other ways of "linking generations through youthful energy and traditional skills."

Mr. and Mrs. Fish Education Program
Gulf of Maine Aquarium
Marine Education Program
21 Vocational Drive
South Portland, Maine 04106
Telephone: (207) 799-6234

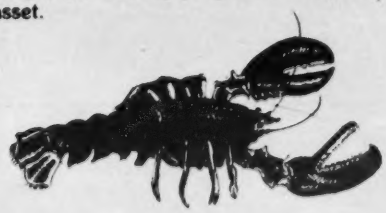
The Aquarium barge on the Portland waterfront is available for visits. The program features all types of creatures, habitats, and hands-on activity. Mr. and Mrs. Fish also travel for a reasonable fee to bring through creative dramatics their special marine magic to your school. Jeff Sandler and Deb Hall are two of the nation's most imaginative and skilled marine educators. No fees are pre-set; call to plan a program with them.

Maine Audubon Society
June LaCombe, Director of Education
Gilsland Farm
118 Old Route One
Falmouth, Maine 04105
Telephone: (207) 781-2330

The Audubon Society sponsors many high-quality natural history, environmental education, and energy education programs. Services available to you for your seashore visit include use of the Teacher Resource Center (in person or by mail, for slide shows and books), field trips to salt marsh environments, and advice. Bruce Jacobson, Resident Naturalist at Maine Audubon's Mast Landing Wildlife Sanctuary in Freeport is a marine education expert and could provide additional services. He may be contacted directly at (207) 865-6756.

Chewonki Foundation
Scott Andrews, Director of Environmental Education
Wiscasset, Maine 04578
Telephone: (207) 882-7323

Chewonki offers many top-quality services to teachers. Their great strengths are their sound philosophical base and their enthusiastic, talented staff members. Programs include teacher workshops with credit (offered throughout Maine), in-service workshops on your site, consultation with schools to develop programs, ecology workshops, and five day programs for students in Wiscasset.



State of Maine Department of Conservation
Bureau of Parks and Recreation
Information and Education Division
State House Station 22
Augusta, Maine 04333
Telephone: (207) 289-3821

The Bureau of Parks and Recreation will send information on State Parks and Memorials, many of which make excellent seashore field trip sites. Only one state park maintains a year round, full-time naturalist — Wolf Neck Woods State Park in Freeport. The services of talented naturalist Kate LeRoyer are available to you at the Park or on your site. An outdoor guided nature walk on intertidal zone ecology is a specialty of the interpretive program. To contact the park directly, call (207) 865-4465.

State of Maine Department of Marine Resources
Lorraine Stubbs, Marine Science Educator
State House Station 21
Augusta, Maine 04333
Telephone: (207) 289-2291

The DMR has the ability to work with teachers and schools in setting up programs and planning curriculum. Speaker service with slide presentations can be tailored not only to your grade level, but your particular class interest and needs. Hands-on materials and answering questions are part of the presentation. Publications for use by teachers, which are free of charge, are abundant in the DMR library, as are many technical reports for teacher background material or intensive study projects by students. The department will also arrange for visits to aquaria or research labs. The highly-knowledgeable and skilled Lorraine Stubbs is responsible for these diverse and high-quality services.

University of Maine Sea Grant Marine Advisory Program
Sea Grant Office, Coburn Hall
Orono, Maine 04469
Telephone: (207) 581-2666

Sea Grant has many research and commercial fishing publications available, primarily of a technical nature. One resource we recommend for your age group is *Marine Fisheries Of Maine*, a series of six color filmstrips with cassette tapes. It is available for purchase or you may find it at your local resource center. The Marine Advisory Service and the Cooperative Extension Service of Orono have recently published an excellent informal marine education guide which you would find especially valuable with students of this age group; the activies and teacher background material are top-notch. It is titled *Connections To The Sea: A 4H Guide To Marine Education Activities In Maine* and was written by Gail Shelton and Brenda Roth.

Northern New England Marine Education Project
Dr. John W. Butzow, Director
206 Shibles Hall
College of Education
University of Maine at Orono
Orono, Maine 04469

The primary purpose of this project is the production of marine education materials for use by teachers of Maine and New Hampshire. There are sixteen published multi-disciplinary units on a variety of topics for a range of grades, several of which could be adapted to your grade level. The unit you are now using is the first of five to be produced especially for middle/junior high school use. The project also sponsors workshops in schools, marine education conferences, and summer institutes.

The Nova Scotia Museum
Education Section
1747 Summer Street
Halifax, Nova Scotia
Canada B3H 3A6
Telephone: (902) 429-4610

The Museum offers you publications, resource kits, collections, and responses to specific inquiries. For those living close to Halifax, a broader array of museum resources for school oceanography is available. Call or write for further information.

Resource Persons

These people, either as cooperative extension agents or private individuals, may be contacted for detailed information on field sites or for information on other marine education-related places to visit in their regions. They will, in some cases, provide resources or help you lead your trip.

New Hampshire Seacoast

Julia Steed Mawson, Marine Education Specialist
University of New Hampshire Marine Program
Office of Cooperative Ocean Programs
45 Pleasant Street
Portsmouth, New Hampshire 03801
Telephone: (603) 431-5344 or (603) 862-1347

Sharon Meeker, Coordinator of Volunteers and Special Projects
University of New Hampshire Marine Program
Marine Program Building
University of New Hampshire
Durham, New Hampshire 03824
Telephone: (603) 862-1889

Kittery through Old Orchard Beach Area

Elizabeth C. Syvinski, County Office Chairperson
York County Cooperative Extension Service
Court House Annex
Alfred, Maine 04002
Telephone: (207) 324-2814

Pine Point Beach through Brunswick Area

Dr. Peter J. Horne, Extension Agent
Cumberland County Cooperative Extension Service
96 Falmouth Street
Portland, Maine 04103
Telephone: (207) 780-4205

Boothbay Region (including Westport, Southport, Oceanpoint) **and the Pemaquid Region** (including the Damariscotta River, Damariscove Island, Pemaquid Point, Round Pond, The Rachel Carson Preserve and Salt Pond, to Friendship)

The Darling Center
Walpole, Maine 04573
Telephone: (207) 563-3146

Wiscasset through Camden (including Port Clyde, Tenants Harbor, Spruce Head and Owls Head)

Leslie C. Hyde, Extension Agent
Knox-Lincoln County Cooperative Extension Service
375 Main Street
Rockland, Maine 04841
Telephone: (207) 594-2104

Verona to West Quoddy Head

David Dow, Marine Advisory Program
Sea Grant Office
30 Coburn Hall
University of Maine
Orono, Maine 04469
Telephone: (207) 581-2719

Bar Harbor, Acadia National Park, Lamoine Beach, Winter Harbor, and Prospect Harbor Areas

Wesley Hedlund
Bangor High School Biology Department
885 Broadway
Bangor, Maine 04401
Telephone: (207) 947-6711

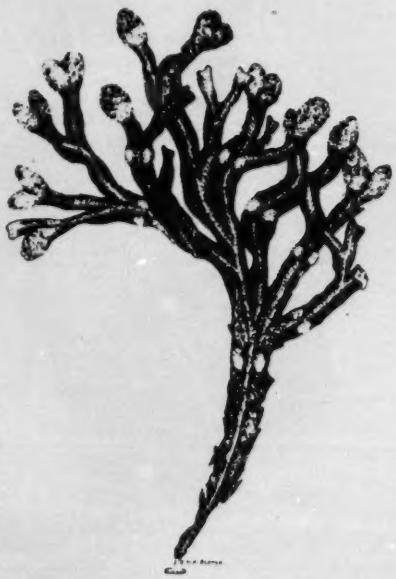
or through the University of Maine at Orono
c/o Dr. John W. Butzow
206 Shibles Hall
College of Education
Orono, Maine 04469
Telephone: (207) 581-7027

Cobscook Bay Region to East Quoddy Head, New Brunswick

Dr. Gayle Krause
University of Maine at Machias
Biology Department
Machias, Maine 04654
Telephone: (207) 255-3313

Lubec Area to Deer Island and Campobello Island, New Brunswick

Dick Glueck
70 Cottage Street
Bangor, Maine 04401
Telephone: (207) 942-0260



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Places to Visit

Aquaria, Museums, and Memorials

Some of these listed places are possibilities for educational stops enroute to your field site. This is particularly true of the coastal memorials, which provide the opportunity to combine human with natural history and don't have as many restrictions on noise and behavior as a museum. Memorials may also be viewed from the outside during the off-season and make good picnic spots.

Other listed places are the small but worthwhile aquaria of our region. We suggest you discuss in detail, in advance the services they can offer you and how you can best prepare your class with pre-trip study.

Marine museums are also listed which primarily house artifacts of our rich maritime heritage. As with the memorials, they have little to offer in the way of marine science but represent good opportunities for students to experience the close relationship of their cultural heritage to the sea.

Strawbery Banke
John Durel, Education Director
Portsmouth, New Hampshire 03801
Telephone: (603) 436-8010

An extensive and tasteful restoration celebrates the richness of three centuries of seaport life in this historical city; it is a maritime heritage museum extraordinaire. Educational packets are available in advance to help you in a self-guided tour. Staff members and volunteers are on-site to answer questions.

Kittery Historical and Naval Museum
Bruce Follansbee, Director
Kittery, Maine 03904
Telephone: (207) 439-3080

This museum, while small, is very worthwhile. Well-trained volunteers provide in-depth descriptions of maritime history and artifacts. The focus is on the Piscataqua River region but Kittery Naval Shipyard history is included. School visits can be arranged.

The Nature Center at Odiorne Point State Park
Route One-A
Rye, New Hampshire

The Nature Center is jointly sponsored by the University of New Hampshire Marine Program, the Audubon Society of New Hampshire and the State Division of Parks. A diversity of marine awareness programs are available at the Center or in your classroom. Teacher workshops are also conducted. ***The Tidepool Times***, an attractive and informative newsletter for youngsters is published by the Nature Center. For information contact: Julia Steed Mawson, Office of Cooperative Ocean Programs, 45 Pleasant Street, Portsmouth, New Hampshire 03801, telephone (603) 431-5344.

Fort McClary
Kittery Point, Maine

An 1846 hexagon blockhouse sits on the site of the first Fort McClary, built in 1809. This place was fortified as early as 1715 by the Massachusetts Bay Colony to protect their merchants from taxes by the Colony of New Hampshire. The fee is 25¢, children under 12 free. Open from May 30 to October 10. (Leave U.S. No. 1 at Rotary in Kittery, south on Kittery Point Road Route 103).

The Gulf of Maine Aquarium
Commercial Street
Portland, Maine 04101
Telephone: (207) 772-2321

The programs available on the barge, which is located directly on Portland's busy waterfront, are tailored to your suggestions as to topics and student ability. The skillful staff offers programs of approximately one hour's length at reasonable rates. Open from mid-April to the end of December on week days, nine to noon, the barge is a very exciting destination. Call for a consultation with the staff.

Fort Popham
Phippsburg, Maine

Fortifications here guarded the Kennebec River during the Revolution, the War of 1812, the Civil War, and the Spanish-American War. The present granite fort, never completed, dates to 1861. In 1607, the English made an attempt to start a colony nearby where the first American ship was built. Fee is 25¢, children under 12 free. Open from May 30 through Labor Day. (Fifteen miles from Bath on Route 209.)

Maine Maritime Museum
963 Washington Street
Bath, Maine 04530
Telephone: (207) 443-6311

This is one of the finest museums of its type anywhere. There are four sites to visit and they represent a full day's visit or more. The Sewall House is an 1844 mansion housing maritime collections and artifacts in interpretive displays. Winter Street Church contains thematic exhibits, historic photographs, and local maritime history. The Percy and Small Shipyard is the only surviving enterprise to have built large wooden sailing vessels. The Apprenticeshop, which offers instructional programs for future boatbuilders, may be visited and works-in-progress viewed from the loft. The Sewall House is open year round, the other sites from May 16 to October 26. Group rates are available at 50¢ to 70¢ per student depending upon the number of sites visited.

Fort Edgecomb
North Edgecomb, Maine

The 1808 octagon blockhouse and outwork fortifications were built to protect Wiscasset. The fort overlooks Sheepscot River, often a good seal watching spot. Fee is 25¢, children under 12 free. Open May 30 through Labor Day. (South of U.S. No. 1 at Edgecomb end of Wiscasset bridge, then next right.)

Bigelow Laboratory for Ocean Sciences
McKown Point
West Boothbay Harbor, Maine 04577
Telephone: (207) 633-2173

This is an independent lab sharing research and library facilities with the Maine DMR. School classes may visit and view the aquarium tanks and tour the site. Make advance arrangements through Lorraine Stubbs, Marine Science Educator, Department of Marine Resources, State House Station 21, Augusta, Maine 04333, Telephone: (207) 289-2291.

Grand Banks Schooner Museum
100 Commercial Street
Boothbay Harbor, Maine 04530
Telephone: (207) 633-5603

Exhibits offer insights into the early Maine fishing industry. The 142 foot dory schooner, *Sherman Zwicker*, may be toured above and below decks. Open June 1 to Labor Day with weekends to mid-October. Group rates available at 50¢ for children with accompanying adults free.

Maine State Museum
State House Complex
Augusta, Maine 04333
Telephone: (207) 289-2301

The museum has concentrated its resources in recent years on exhibits, and their work is handsome. Although not specifically limited to marine concerns, their exhibits effectively interpret Maine's diversity of marine, aquatic, and terrestrial environments. The newer exhibits focus on the traditional human relationship with land and sea. Museum tours and classes may be arranged free of charge. The choice of museum programs for your grades include: What Is A Fish? (Grades 2-6), The Web Of Life (Grades 5-6), and Salmon Stakes (Grades 7-12). Please schedule with Vera Lincoln, Division of Community Services, State House, Station 73, Augusta, Maine 04333. Telephone: (207) 289-3771.

Colonial Pemaquid
Bristol, Maine

The site of extensive archeological excavation work, the area includes foundations of homes and fortifications from 17th and 18th century settlements. Colonial and Indian artifacts are displayed in the Museum. Museum fee is 50¢, 25¢ for children 6-12. Fort William Henry fee is 25¢, children under 12 free. Restaurant on site. Open from May 30 through Labor Day. (Route 129 to 130 from Damariscotta.)

Penobscot Marine Museum
Searsport, Maine 04974
Telephone: (207) 548-6634

This is an exceptionally fine museum with an education department and services to visitors of any grade level. The Searsport area, long recognized for its deep water ship masters and its shipbuilding prowess, became the repository of treasures from the Orient, well-crafted instruments of navigation, and tools employed in the building of Downeast vessels. These items, plus ship models, ship portraits, and the sea captain's homes which are part of the complex of buildings are the Museum's strengths. It is open daily from May 25 to October 15. Group rates are 25¢ per student for the tour plus 25¢ each for a class experience. The Museum teacher is available to take programs into your school for only 15¢ per mile round trip from Searsport.

Fort George
Castine, Maine

Earthworks and fortifications were erected by the British in 1779 and were the scene of the Revolutionary War battle in which Americans were repulsed. The fortifications were again occupied and improved by the British in the War of 1812. There is no fee. Open May 30 through Labor Day. (Route 166 to Castine.)

The Allie Ryan Maritime Collection
Maine Maritime Academy
Castine, Maine 04421
Telephone: (207) 326-4311

The collection, gift from Mr. Allie Ryan of South Brooksville, focuses on 19th century sail and steam. It contains primarily models and portraits of ships. The museum is small, but very worthwhile. Admission to groups is free with advance notice. Open year round, Tuesday through Saturday. While in Castine you might like to tour the 533 foot Training Vessel *State Of Maine*, a fine example of the American 1950's military transport ship.

The Oceanarium
Dave and Audrey Mills, Directors
Post Office Box 622
Southwest Harbor, Maine 04679
Telephone: (207) 244-7330

The Oceanarium has exhibits on fish gear and commercial fishing as well as tanks for viewing and touching. Slide shows and stories on lobstering are available. Open May 15 to October 21. Nominal charge for each student. The directors also offer school visitation programs.

Fort O'Brien (also called Fort Machias)
Machiasport, Maine

Site of fortifications erected by Americans in 1775, overlooking Machias Bay; it was the scene of the first naval engagement of the Revolution. The breastwork remains on this site were erected in the Civil War. There is no fee. Open from May 30 through Labor Day. (Five miles from Machias on Route 92.)

The Huntsman Marine Laboratory Aquarium
St. Andrews, New Brunswick
Canada

The laboratory is a research and educational foundation with many services including courses of interest for teachers. The aquarium includes tanks and displays designed to inform visitors about the local waters' inhabitants. Popular with students are the "Please Touch" tank and Harbour Seal Pool open May 26 to September 10. The fee is 50¢ for ages 6 through 15.

Field Sites

Hampton Beach State Park, Rockingham County

Location: On Route 1A in Hampton, New Hampshire near the Seabrook-Hampton town line.

Description: Located at the edge of Hampton Harbor, this park offers views of the harbor's activities, Isles of Shoals, and the coast of Massachusetts to the south. Its primary features are a sandy beach, small primary dunes, and a long jetty extending into the harbor mouth. To the north the beach continues into the more commercialized sections of the Hampton shore.

Ragged Neck State Park, Rockingham County

Location: On Route 1A in Rye, New Hampshire, 1/4 mile north of Rye Harbor. Salt marshes can be seen intermittently all along the landward side of Route 1A.

Description: This small park has been developed on a rocky headland at the mouth of Rye Harbor. A jetty, rocky shore, and cobble beach offer good sites for exploration.

Wallis Sands State Park, Rockingham County

Location: Route 1A, Rye, New Hampshire

Description: For beachgoers, Wallis Sands State Park is a favorite place. The park offers visitors a small shady beach in a less commercialized area of New Hampshire's seacoast. A rocky shore borders the park to the north and a large grain beach delineates the park's boundary to the south.

Odiorne Point State Park, Rockingham County

Location: On Route 1A, 3 miles south of Portsmouth, New Hampshire, in Rye

Description: Odiorne State Park is currently one of New Hampshire's last underdeveloped stretches of shoreline. The park has several miles of walking trails that meander through secondary growth woods and fields.

New Castle Commons, Rockingham County

Location: On Route 1B, New Castle, New Hampshire, 1/4 mile north of Wentworth-By-The-Sea.

Description: The Common is a small reserve situated on historic New Castle Island. Explorers of its rocky shores will have grand views of Whaleback Lighthouse and the comings and goings of Portsmouth Harbor. Contact the Selectmen, New Castle, New Hampshire for information.

Great Bay Estuary

Description: This in-land water system is considered to be one of the largest estuaries north of Chesapeake. Freshwater is brought to Great Bay and Little Bay through several rivers; the Cocheco, Salmon Falls and Bellamy are three of the more prominent. From the east the Piscataqua River links the estuary to the sea. Though largely under private ownership, there are few access points for the public.

Hellon Park, Strafford County

Location: On Route 4 in Newington, New Hampshire, near the bridge

Description: This small park is rimmed by a rocky and cobble shore located on Thurber Straight. The park is bordered on one side by Little Bay and the Piscataqua River on the other.

Adams Point, Strafford County

Location: Off Durham Point Road, Durham, New Hampshire

Description: Thousands of years ago the mighty glaciers sculptured Great Bay. One of the prominences left during the process was Adams Point. Though currently under the jurisdiction of the New Hampshire Fish and Game Department, the land for many years belonged to the Adams family. A walking trail first passes by salt marshes and through woods and then follows the edge of the shore. Visitors can continue to follow the water's edge or walk through nearby fields. The Jackson Estuarine Laboratory is also located on Adams Point.

Rachel Carson National Wildlife Refuge Dedication Area, Cumberland County

Location: On Route 9, 1 mile north from Route 1 intersection, in Wells, Maine

Description: Tucked behind the barrier beaches and islands of Southern Maine, acres of tidal wetlands are preserved as part of the Rachel Carson National Wildlife Refuge. Though scattered from Kittery to Portland, Maine, the main headquarters is located in Wells, Maine. At this site, a one mile loop trail meanders through pine woods and then past the tidal creeks of the salt marshes beyond. Information about access points for other sites of the Rachel Carson Refuge can be obtained from Morris Mills, Refuge Manager, by calling (207) 646-9226.

Ogunquit and Moody Beaches, Ogunquit and Moody, York County

Location: Route 1 to Ogunquit

Description: Ogunquit and Moody Beaches compose the longest barrier spit in Maine. For many years, the Ogunquit dunes were greatly affected by the Northwest winds, which created the largest parabolic dunes in Maine. A classical illustration of summer as opposed to winter beach face profile types is also evident. The sand is of a uniformly fine, nearly pure quartz. The botanical community consists of pitch pine as climax species, beach heather, beach plum, seaside spurge, and wormwood, as well as the usual species that dominate a sand beach system in Maine, such as American beach-grass, beach pea, dusty miller, saltwort, sea blite, and sea rocket.

Laudholm Beach, Wells, York County

Location: Off of Route 9 between Wells and Kennebunk

Description: Laudholm, Crescent Surf, the Little River reentrant, and the back-barrier marshes represent the best illustration in Maine of a sandy double barrier spit-tidal river and marsh system remaining in a natural state. Laudholm consists of poorly sorted, coarse sand, pebbles, cobbles, and boulders; which suggests recent transport from a local till source. There is poor zonation at the southern half of the back dune, but there is obvious zonation at the northern half of the beach where the aeolian sand supply is the greatest. The botanical community consists of wormwood, pitch pine, beach heather, and earthstar puffball, in addition to the usual community of species — beach grass, beach pea, sea blite, salt wort, sea rocket, and dusty miller.

Parsons Beach, Kennebunk, York County

Location: Off of Route 9 between Wells and Kennebunk

Description: Parson's Beach is a small barrier spit and salt marsh complex. Such beaches are important because they protect the salt marsh behind them. The presence of wormwood and the starry false solomon's seal are unusual.

Crescent Surf Beach, Kennebunk, York County

Location: Off of Route 9 between Wells and Kennebunk

Description: Crescent Surf Beach is a small barrier spit with back-barrier tidal river and salt marsh. The beach is unique in that the total area is accretionary; the aeolian ramp, berm, and beachface are all well-developed. Some botanical species present include beach heather, wormwood, seabench sandwort, lichens, earthstar puffball, pinweed, and pitch pine.

Kennebunk Beach, Kennebunkport, York County

Location: Route 9, south out of Kennebunkport, left at the four corners, follow the signs

Description: This beach is mostly made up of rounded beach stones called shingles. There are some isolated tidal pools. It may yield some interesting driftwood or other flotsam.

Biddeford Pool, Fortune Rocks, Goose Rocks, and Hoyt Neck, Biddeford, York County

Description: All of these areas are reached from the town of Biddeford off Routes 9 and 208. Hoyt Neck is typical. It is made up of rounded granitic rock. The whole area has the appearance of fingers with huge boulders, cracks, crevices, and tidepools between the fingers. Although many of these areas do not offer textbook zonations, many intertidal flora and fauna may be seen. In particular, all four types of periwinkles, hermit crabs, blood and brittle starfish are worth noting.

Scarborough/Marsh, Scarborough, Cumberland County

Location: On Route 9 near Pine Point

Description: Maine's largest marsh is best visited through the Scarborough Marsh Nature Center sponsored by the Maine Audubon Society. It is open from April through October. There are two naturalists available for tours of two hours duration. This is an excellent educational experience which also introduces students to three different environments; dunes, marshlands, and tidal pools. This is a hands on sensory approach. Introductory materials, reading lists, and follow-up activites are supplied through the Maine Audubon Society, Gilsland Farm, Falmouth, Maine 04105; Telephone: (207) 781-2330.

Prouts' Neck Area, Scarborough, Cumberland County

Location: Off Route 77, follow signs

Description: Jordan's Beach (also called Scarborough Beach) has access to the whole east side of Prouts' Neck. About 1.5 miles of sandy beach stretch this site. The area is bounded by rocky ledges on each edge. There is a long stretch of beach on the west side as well. Ferry Beach (also called Western Beach) will bring one into this area. Parking facilities are available. There is a small fee in the state park season. This area does not abound in rocky intertidal life but numerous dried specimens of razor clams, sand dollars, horse shoe crabs, moon snails, soft shell clams and hen clams may be found in the flotsam. One may also view Pine Point Beach from this site. The whole area between Pine Point and Old Orchard would result in similar findings on the sandy beaches.

Higgins Beach, Scarborough, Cumberland County

Location: Off Route 77, follow signs

Description: The sandy part of this beach has been washed out partially from winter storms. To the right of this are rocky intertidal areas which can be reached along a foot path to the right of the beach.

Two Lights State Park and Crescent Beach State Park, Cape Elizabeth, Cumberland County

Location: Both off Route 77, follow signs

Description: The highly eroded metamorphic rocks resemble pretrified trees lain side by side giving a slabby step-like appearance. There are many sizable tidepools at all tide levels. The zonation is obvious, but not sharp because of the flatness of the slope. The upland area consists of a parking lot and grass. The Irish moss zone consists of a thick mussel-moss mat which is home for numerous round, segmented and ribbon worms. Kelp is dominant in the lower zone. Sea lettuce and filamentous red algae, bladder wrack and knotted wrack are a few of the algae. Limpets, whelks, arctic clams, barnacles, northern stars, brittle stars, isopods, and bread crumb sponges may be found in the intertidal pools. Green and rock crabs are sometimes evident, too. There is a great amount of diversity at this location. This park is also close to Crescent Beach State Park where an excellent sand beach is located. Strand lines, discarded hen clam shells, flotsam and jetsam are abundant here.

Port of Portland, Portland, Cumberland County

Description: There are no large ledge areas along the Portland waterfront but the pier pilings offer areas of study. The gravely sandy areas of Eastern Promenade, specifically Fish Point, offer some intertidal organisms. The harbor could be the focus of an unlimited number of studies though; such as oil transport, cargo movements, tug boat operations, historic sites, ship repair, Coast Guard operations, pollution abatement, and so on. This harbor is a good jumping off point for the Calendar Islands of Casco Bay. Casco Bay Lines offer cruises; they are located at Commercial Street, on Custom House Wharf, telephone (207) 774-7871.

Bailey Island Area, Harpswell, Cumberland County

Location: Down Route 24

Description: Many very productive areas for visiting are found along Route 24. This region has been quantitatively sampled by the Bigelow Laboratory in an intertidal inventory study for the Maine State Planning Office. Sixty-four different plants and animals have been identified here. Most of the organisms listed in this field site guide and, in addition, sea squirts, flat worms, and hydroids may be located here. A lot of the rocky areas have 60° to 80° slopes which give a tremendous range of isolated tidal pools. Kelp is found slightly subtidally. The lower tidal pools are continually flushed with seawater and will provide the greatest diversity of life.

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Reid State Park, Georgetown, Sagadahoc County

Location: Off Route 127, from Woolich at Carleton Bridge 14 miles to the park entrance

Description: Northernmost dune area in Maine, this area can be a good study of barrier beach maintenance in relation to sea level rise. It is unique because the beach is very large, considering that the sand is locally derived. There is very little sand offshore — primarily it's rocky-bottomed. It is an excellent area with all the necessary features for group visits. The coast consists of 1.5 miles of sand beaches, dunes, marshes, and ledges. The rocky intertidal area is made up of metamorphic rock — mostly schist. The area is constantly exposed to the open ocean. Some of the algae reflect the stress from the pounding waves.

Popham Beach State Park, Popham Beach, Sagadahoc County

Description: An extensive beach of light, fine sand, a sand bar with tidal pools, and rocky outcrops may be explored here. It is one of the largest and most complex beach systems in Maine. Relict shorelines, possibly 290 years old, are found behind Popham Village in a small salt marsh. Possible former marine lagoon which is now a freshwater lake — Silver Lake. One of the best illustrations of very unstable natural geological processes; major shoreline changes have ocurred in short periods of time. Extremely variable beach profiles. Sand bars are the only ones of this size in Maine.

Seawall Beach, Phippsburg, Sagadahoc County

Location: Route 1 to Bath, Route 209 to Phippsburg, follow signs to Popham Beach State Park. At low tide, one can cross the Morse River at the western end of Popham Beach, and end up on Seawall Beach.

Description: Seawall is of particular importance because it is the largest, undeveloped barrier spit in Maine. The other ones (Ogunquit-Moody, Wells, Camp Ellis, and Old Orchard) have been greatly altered by development. For this reason, it is a good lab for studying barrier maintenance, sedimentary events of the Kennebec River, and sea level rise effects. Seawall has an incredible diversity of dune vegetation. Dominant species include American beach grass, beach heather, bayberry, pitch pine, meadowsweet, beach pea, and raspberry.

Cape Newagan, Southport, Lincoln County

Location: Route 238 from Southport Village, follow to the point past village of Newagan. The point may be seen from the road.

Description: The cape is exposed to the southwest and the upland area consists of a number of cottages set in the spruce trees. It is protected to the southeast by Cape and Hunting Islands. Slope is variable from 5° to 70°. Zonation is distinct and many common species of plants and animals may be observed. In addition, the flowering anemone may be seen in tidal pools.

Ocean Point, Boothbay Harbor, Lincoln County

Location: Route 96 from East Boothbay, follow signs

Description: This area is bounded by three large summer cottages. It has mostly granite ledges with some metamorphic rock and is partially protected to the southwest by Fishermen's and Green Islands. The intertidal zonation is well defined. The degree of beach slope is up to 30°. The area is covered with Irish moss, coralline algae, sea lettuce, filamentous green and brown algae, kelps, rockweed. Animals include roundworms, limpets, three different types of periwinkles, whelks, blue and ribbed mussels, boring bivalves, rock crabs, green crabs, northern star and sea urchin, nudibranches, and blood stars. Isopods and the rock blenny fish may be found in the lower tidal pools. The barnacle and periwinkle zones are well defined, too.

Pemaquid Point, Bristol, Lincoln County

Location: Route 129 from Damariscotta to Route 130 and follow to its terminus

Description: This is an ideal area to study a rocky shore. It is composed entirely of granite rock ledges. The tidepools are large and numerous. The upland area has a few spruce trees. A parking area is available. There are rockweed, thick growths of Irish moss, mats of blue mussels, sea lettuce in protected areas, and coralline algae encrusting rock surfaces. There are a number of species commonly found in tidal pools. The bread crumb sponge, scale worms, limpets, whelks, the northern starfish, sand worms, nudibranches, and brittle stars also abound here. The barnacle zone is well developed. The most common animal is the periwinkle.

Pemaquid Beach, Bristol, Lincoln County

Location: Route 1 to Damariscotta, Route 129 out of town until it intersects with Route 130. Follow this to Pemaquid, the beach is on the western side of Pemaquid Neck.

Description: Like Reid State Park Beach, Pemaquid is a closed pocket barrier with a salt marsh in the back — excellent example. The main beach has a great deal of mineralogic sorting due to the processes of erosion and deposition. The rarity of dune habitats as one moves east makes this beach significant.

Port Clyde Lighthouse, St. George, Knox County

Location: Route 131 from South Thomaston to Port Clyde, then ask for directions to the light

Description: This beach area around the lighthouse is protected from the south but open from the southeast. There are numerous crevices and small tidepools at all tidal levels. The zonation is indistinct but life abounds; clumps of Irish moss, kelp, rockweed, thread-like green algae, dog whelks, periwinkles, blue mussels, round worms, starfish, hermit crabs, brittle stars, amphipods, sea urchins. There are also many broken shells in the crevices. Parking is available near the lighthouse keeper's house.

Deep Cove, St. George, Knox County

Description: There is a series of four beaches along this cove between Hooper and Howard Points. A wide range of intertidal life is available here in a mix of different types of shores.

Rockland Breakwater and Lighthouse, Rockland, Knox County

Location: U.S. Route One to Rockland, seek directions to Beacon Point

Description: The breakwater is located at the tip of the point. Intertidal forms may be viewed all along the edges at low tide.

Camden Harbor, Camden, Knox County

Description: During extreme low tide conditions rockweeds, periwinkles, starfish and other forms may be seen. There is a lot of fresh water mixing from a stream out of Megunticook Lake, so the diversity of life is not as high here as in open ocean areas. Some colonization of life may be viewed on wharf pilings. This is a good area to view boat traffic and get a glimpse of the schooners.

Moose Point State Park, Searsport, Waldo County

Location: Between Belfast and Searsport on U.S. Route One

Description: This is a very scenic view of Penobscot Bay. It has a gravel and rocky beach. Some intertidal forms may be observed.

Castine Area, Castine, Hancock County

Location: From Bucksport Route 175 to 166A

Description: If you have a couple of scuba diving friends, collections can be made under the town wharfs next to the Maine Maritime Academy's ***State of Maine*** merchant ship. This is an excellent collecting ground for old scallop shells (good for scrimshaw work), starfish, sea anemones, sea urchins, nudibranches, blue mussels, whelks, and encrusting algae. Follow Route 166 back out of Castine to Route 175. You will see a mud flat or cove area on your right and a sign marked the "British Canal 1776" on your left. Take the first road to the left and a sandy gravel beach will come into view. This beach has good strand lines, patches of blue mussels, soft shell clams, rockweed and barnacles. Digging is necessary to obtain the clams. Sandworms and blood worms are also found here. On the opposite side of the road, a small lagoon has sticklebacks and mummichogs. This whole area is rich in history of the American Revolution.

Blue Hill Falls, Blue Hill, Hancock County

Location: Route 175 from town to the south to the concrete bridge

Description: These are the reversing falls from the Salt Pond. At low tide hermit crabs, blue mussels, barnacles, sea urchins, periwinkles, and a host of intertidal life is available here. In the summer such things as beach peas, salt wort, and Irish moss could be collected for pressings and later use.

Trenton to Bar Harbor Area, Including Acadia National Park, Hancock County

Location: Route 3 from Ellsworth to Mount Desert Island

Description: Under the Trenton bridge collections of dulse can be made and numerous periwinkles found; other forms of red algae can be viewed from spring through to the fall. An information center is located beyond this bridge. Follow Route 3 to Acadia Park entrance. Stop at the visitor center. Exhibits, park informatoin and maps will be of value. Leave the center and take the Ocean View Drive road. Some of the most spectacular ocean and island views in Maine are along here. You may want to take a side excursion to Chamberlain Mountain first.

The second stop along the ocean drive is Sand Beach. The beach is composed of minute animals shells, not silica. Sea urchins' spines and mother-of-pearl may be examined with a hand lens. Rocky ledges are located on the left and right sides of the long beach. Some zonation is evident.

This beach has a larger volume of sand per meter of beach length than any other beach north of Pemaquid except Roque Island Beach. The origin of about half of the sand is biogenic rather than glacial, but there is a cobble/boulder beach or lag surface beneath the sand of the seasonal berm at each end of the beach. It is the only purely sandy beach in Maine that has such a high carbon concentration.

Follow the road beyond to Thunder Hole. This is well-named and self explanatory. Beyond this are the Otter Cliffs. Vertical zonation is good here. Three or four miles beyond this on the one way drive Otter Cove is located. Strand lines and beach shells are bountiful there. About 1.5 miles further is Little Hunters Beach. A walkway leads from a stone bridge down to a cobblestone beach. There are a few tidal pools and good intertidal forms located here.

Lamoine State Park and Public Beach, Lamoine, Hancock County

Location: Route 184 from Ellsworth

Description: The park, on Frenchman's Bay, has a sandy beach environment as well as rocky intertidal areas. The public beach is gravel with a rocky ledge. Zonation, strand lines, flotsam and jetsam may be viewed.

Ellsworth to Schoodic Point, Hancock County

Description: For those schools in Penobscot, Hancock, and even Piscataquis counties, an excellent all day trip may be made here with many geological, typical shore, and intertidal life observations. Approximately 150 yards above the Union River Bridge on Route 1A the Ellsworth Schist may be seen. This is an outcropping of ledge on the right hand side of the road. Glacial striations may be seen in the rock where the last glacier passed, ten to fifteen thousand years ago. Follow Route 1A to the intersection with Route 3. Take a right here and follow this road out about 6 miles. On the right hand side you will see a gravel pit. A stop here will reveal geological features such as ancient river deltas and old river beds which one may see in the cut-away landscape. This road leads back onto 1A. Follow this and about 6 miles beyond, there are some beautiful views of the Mount Desert Island mountains which were also formed by the glacier. A few miles beyond this Long Cove may be seen. This is an excellent mud flat study area. At low tide carpets of green algae are evident as well as sticklebacks, mummichogs, sand shrimps, soft shell clams, eel grass, periwinkles, and mud snails. A lagoon is located at the head of this cove and offers typical rocky shore zonation as well as reversing tides. One may walk the shoreline to get to this spot. After this visit, follow Route 1A to Sullivan Bridge. Continue on Route 1A to Route 186 into the town of Winter Harbor. Follow the signs to Acadia National Park. The first stop as you come into the park is Frazier Point. Restrooms are here. A clamming area and rocky area with some zonation may be viewed. Driving along the one way road beyond this at least five or six exciting stops may be made. Stack and boulder beaches of the pink granites, excellent zonation, surf, steep cliff walls and excellent views of Ironbound, Turtle and West Pond Islands all make this worthwhile. The grand finale is a visit to Schoodic Point. The one way road leading back to Winter Harbor offers more beaches to be seen.

Grindstone Neck Beach, Winter Harbor, Hancock County

Location: Follow Route 186 into town, take a right turn at the intersection of 186 and the Main Street. Follow this road .5 miles beyond town. Turn right onto Grindstone Neck Road.

Description: This beach shows some interesting geology and zonation. Pink granites and basaltic dikes may be viewed here. Blue-green algae grows profusely on the rocks which are very smooth from the pestal and mortar action or grinding of the round cobble stones on the ledges. This makes them very slippery. There is good variation of algal and animal forms including sea

anenomes in isolated pools. One may also leave the Grindstone Neck Road and turn left onto the Main Road. Follow the main road another half mile and take a left onto a dirt road. This leads down to a number of rocky beaches in Deep Cove which offer good geology and zonation features.

Corea and Prospect Harbor, Hancock County
Location: Off Route 195
Description: Prospect Beach is one cove northeast above the town of Prospect Harbor. This beach offers views of strand lines and bordering the sides are rocky ledges which offer good zonation and isolated tidal pools. Northwest of this beach the ledges extend out into shallow water to small rocky islands. There are numerous organisms that may be viewed here on a good low tide. Representatives of green, red and brown algae, large kelps, starfish, sea cucumbers, hermit crabs, whelks, periwinkles, sea urchins, and even sand dollars are found here.

Sandy River Beach, Jonesport, Washington County
Location: West of Jonesboro on Route 1, take Route 187 south along Chandler Bay. At one point, the road runs quite close to the beach
Description: Sandy River Beach is the northernmost sandy barrier-spit in the eastern United States, though Lubec has a long gravel/cobble barrier. This provides a bridging of habitats, dune plants, and beach macrofauna. This beach, together with nearby Roque Island and Roque Bluffs beaches contain most of the American beach grass between Mt. Desert and Lubec.

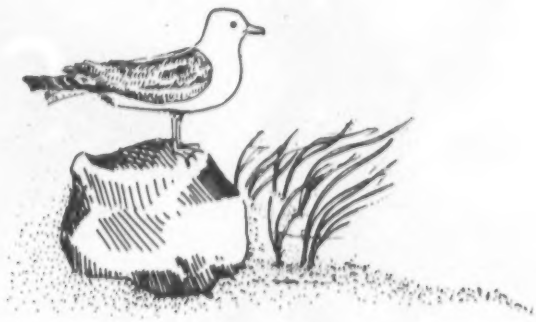
Jonesport Town Park, Jonesport, Washington County
Description: This area yields mixed gravel, sand, and muddy bottoms. There are outcroppings of rockweed and tidal pools offering a diversity of life. This locale is good from the commercial aspect of a coastal community also. Economic life centered around lobstering and pounds, purse seining, gill net fishing, worming, and clamming may be observed.

Roque Bluff Beach, Roque Bluffs, Washington County
Description: This is a long, sandy beach with rock ledges on either side. One extends out well into the ocean. Brachiopod fossils are found in this area. The site is characterized by steep granite bluffs about forty feet high. The zonation is good here. There is not an abundance of tide pools, but there are large cracks which retain water and allow a great diversity of life forms. The barnacle zone is well developed with patches of mussels and their associated life, rockweed, sea lettuce, red algae, bread crumb sponges, the dog whelk, amphipods, encrusting algae, the marine insect *Anurida*, two different periwinkles, and the limpets. A salt pond is located behind the beach. One can study the sand dunes, too.

Jaspers Beach, Washington County
Location: In Howards Cove between Bucks Harbor and town of Starboard
Description: A pathway to the right of the two radar domes leads to a cove at the bottom of the hill. Semiprecious stones may be seen on the cobble beach. There are ledges at each end of the mile long strand with a brackish water pool behind the extensive marsh. Purse seining may be observed from this site.

Reversing Fall Town Park, Pembroke, Maine
Holmes Bay, Whiting, Maine
Cobscook Bay State Park Region
Cutler Municipal Wharf, Cutler, Maine
West Quoddy Head State Park, Lubec, Maine
Deer Island, New Brunswick
Campobello Island, New Brunswick

For location and description details of these Washington County, Maine and New Brunswick, Canada sites you may contact Dr. Gayle Kraus, University of Maine at Machias, Machias, Maine 04654, telephone (207) 255-3313 or Wesley Hedlund, Bangor High School, Bangor, Maine 04401, telephone (207) 947-6711 or Dick Glueck, 70 Cottage Street, Bangor, Maine 04401, telephone (207) 942-0260.



A Note on Respect for the Field Site and Its Inhabitants:

Please remind students that your group's visit to the shore is only temporary and that the plants and animals must continue to live in their habitat after you have gone back to yours. If you pick up a stone, put it back the way it was found. If you pick up an animal, put it down where it was found. Perhaps the most important thing to remember is that the intertidal zone is a fragile and delicate environment. Although it may be tempting to gather one of everything to take home with you, doing so can drastically alter the area as well as deplete the population of organisms that would be available for study by other groups planning to visit the same site.

From a University of New Hampshire Marine Advisory Program Publication

Annotated Filmography

These 16mm films are available from the Instructional Systems Center, Shibles Hall, University of Maine, Orono 04469. They are appropriate to middle and junior high school age students.

The Endless Sea
This 28 minute film examines the attraction and importance of the sea for people. Extensive underwater photography is utilized effectively. Ocean resources, the dependency of Japanese culture on the sea, the ocean's future, and scientific study are emphasized. The film was produced by the National Film Board of Canada in 1971.

Marine Animals and Their Food
This black-and-white film is older — but instructive. It is eight minutes long and deals with feeding behavior.

Marine Life
Although dated and anthropomorphic, this film describes well the biological and ecological adaptation characteristics of various species. The eleven-minute film was made at Marineland and concentrates on southern species. The photography is excellent.

Maine and the Sea
This filmstrip from the Downeast Discovery Series relates Maine's unique historical and contemporary ties to the marine environment. It is from a series which includes several good strips and tapes. Further information is available from Downeast Discoveries, Post Office Box 52, Brunswick, Maine 04011.

Marine Fisheries
A series of six color filmstrips with cassettes produced by the University of Maine Sea Grant Program. Topics are Clam Digging Downeast, the Gill Netters Day, the Lobsterman, Onboard a Trawler, Scallop Fishing in Maine, and Sailing Along the Maine Coast. The set is available from Maine Sea Grant Publications, Coburn Hall, University of Maine, Orono, Maine 04469.

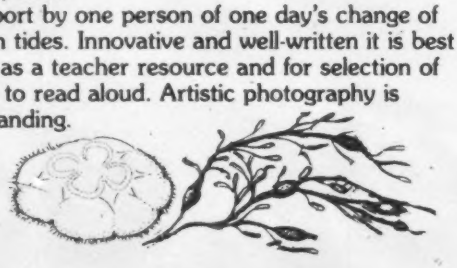
Annotated Bibliography

Many fine books and even bibliographies are available. Your school or local librarian could help develop resource materials boxes to accompany this unit. These books are the best in the Project's experience, for grades five through nine.

Amos, William H. ***The Life of the Seashore.*** New York: McGraw-Hill Book Company, 1966.
From "Our Living World of Nature" series, published in cooperation with The World Book Encyclopedia, this volume is first rate. It is beautifully illustrated, well-organized, and has a good writing style. Uses an ecological approach with specific examples. Highly recommended.

Berrill, N.J. and Jacquelyn. ***1001 Questions Answered About The Seashore.*** New York: Dover Publications, Inc. 1957.
This inexpensive paperback ($4.00) asks and answers clearly and concisely 1105 questions about seashore topics (tides, seawater, seaweed, jetsam, others) and shore animals (mollusks, arthropods, fishes, shore birds, others). It is an engaging approach; students love to browse this fun book.

Braun, Ernest. ***Tideline.*** New York: The Viking Press, 1975.
A report by one person of one day's change of ocean tides. Innovative and well-written it is best used as a teacher resource and for selection of parts to read aloud. Artistic photography is outstanding.



Buck, Margaret Waring. ***Along The Seashore.*** New York: Abingdon Press, 1964.
Full of accurate, readable information. An excellent resource, illustrated by the author with black and white drawings. Very highly recommended.

Carson, Rachel. ***The Edge of the Sea.*** Cambridge, Massachusetts: The Riverside Press, 1955.
The Sea Around Us. New York, Oxford University Press, 1951.
You may want to read some Rachel Carson yourself before teaching the unit; this great scientist is inspiring, informative and pleasant to read. Selections of particularly exciting descriptions would be good for reading aloud. The abiding love she had for the coast of Maine is worth noting for your students.

Cousteau, Jacques. ***The Ocean World of Jacques Cousteau.*** New York: World Publishing, 1973.
The Art of Motion
The Act of Life
Quest for Food
Invisible Messages
Attack and Defense
A series designed to cover the essential concepts related to life in the sea, it succeeds superbly. The books are lavishly and astonishingly well-illustrated with color photography. Students of this age will benefit from using them as reference materials for their research.

Gosner, Kenneth L. ***A Field Guide to the Atlantic Seashore.*** Boston: Houghton Mifflin Company, 1979.
From the Peterson Field Guide Series, this is a guide to invertebrates and seaweeds of the Atlantic Coast from the Bay of Fundy to Cape Hatteras. The best of the field guides in the Project's experience. Virtually indispensible as an identification and information resource. Very highly recommended.

Gotto, R.V. ***Marine Animals: Partnerships and other Associations.*** London: The English Universities Press, Ltd., 1969.
A fascinating volume which reveals considerable information about biological associations. Your students will say "Yuck," but likely be captivated. Covers parasitism, symbiosis, commensalism, mutualism, epizoism, phorsey, inquilinism, and endoecism. Wow!

Miner, Roy Waldo. ***Field Book of Seashore Life.*** New York: G.P. Putnam's Sons, 1950.
A standard in this area of study, the guide is old but contains very good information.

Newell, Richard C. ***Biology of Intertidal Animals.*** Faversham, Kent, U.K.: Marine Ecological Survey, Ltd., 1979.
A top-notch, but highly technical, reference work for the teacher with a serious interest in the ecological factors which determine the environmental psysiology of marine organisms.

Petry, Loren C. ***A Beachcomber's Botony.*** Old Greenwich, Connecticut: The Chatham Press, 1963.
A series of essays and short articles on shore topics, followed by a black and white identification guide to shore plants. Designed for Cape Cod, it is accurate for Northern New England. Fine illustrations and captions by Marcia G. Norman.

Simon, Anne W. ***The Thin Edge: Coast and Man in Crisis.*** New York: Harper & Row, Publishers, 1978.
This vivid and alarming little volume is recommended to you, the teacher. The author, who writes unusually well, is full of passion, understanding of natural systems and ideas about saving American shores.

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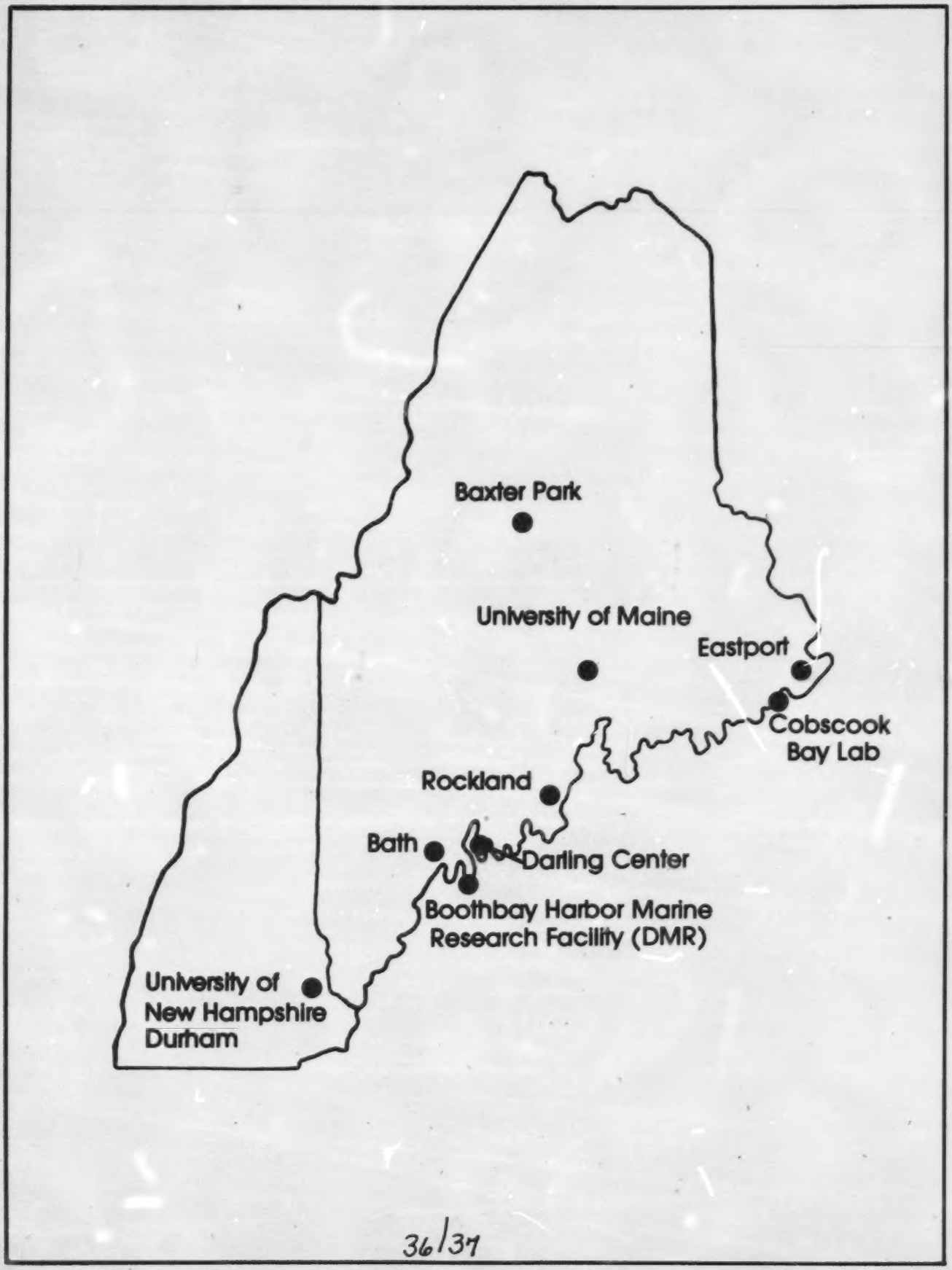
Baxter Park
University of Maine
Eastport
Cobscook
Bay Lab
Rockland
Bath
Darling Center
Boothbay Harbor Marine
Research Facility (DMR)
University of
New Hampshire
Durham

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Common Invertebrates of the Intertidal Zones of Northern New England

Phylum *Porifera*, The Sponges

The Sponges have sessile, non-moving bodies made up of many cells. Inside they have hollow tubes with many pores or canals. Their skeletons are made of many fibers called spicules.

Crumb of Bread Sponge
Halichondrea panicea
This, the most common species, encrusts rocks and overhangs crevices. It can be found in a thick blanket several feet across.

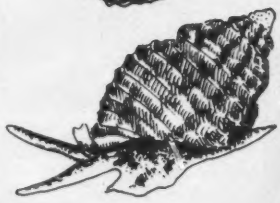
Phylum *Molusca*, The Shellfish

These organisms have a shell-covered soft body within which liquid circulates. The Shellfish are subdivided into two classes. *Gastropoda* have one large shell with an operculum or trap door covering the opening. *Bivalva* have two nearly equal shells or valves and a muscular foot.

Class *Gastropoda*, the Snails

Periwinkle
Littorina littorea
Several species qualify as periwinkles. These small coiled animals are herbivores. They rasp algae growth on rocks from the splash area to the low water mark.

Dogwhelk
Thais lappilus
A dull white, small animal with a banded groove around the operculum. Whelks have a projection which extends in front of them. They are flesh eaters specializing in barnacles, blue mussels and other shelled prey. They drill through the shells into the victim's soft tissue.



Waved Whelk
Buccinum undatum
These are much like the dog whelk although larger and have a more prominant spire at the end of the shell coil.

Tortoiseshell limpet
Acmaea testudinalis
This is one limpet usually seen in our area. Its shell is conical with an unspiraled top and looks like an old-fashioned lamp shade. These herbivores browse on algae in intertidal pools.

Class *Bivalva*, the Clam-like Creatures

Blue mussel
Mylilus edulis
These violet blue to light blue creatures are deliciously edible as their Latin name points out. Caution should be used, however, in eating these organisms when taken from polluted areas. Mussels concentrate pollutants and are much slower than other bivalves in cleaning themselves of the organism causing paralytic shellfish poisoning (PSP). The mussel grows in clusters with the beak end of the shell tied down by tough byssal threads. They often colonize rock faces exposed to extreme wave action but can be found almost anywhere in the intertidal area where a permanent place for attachment exists. Mussels often compete with barnacles for space.

Softshell Clam
Mya arenaria
To Northern New Englanders this is *the* clam. This bivalve has a chalky white to gray elliptical shell and a long black neck. They live buried in soft bottoms such as sand or mud and are found in both the midlittoral and sublittoral areas.

Phylum *Annelida*, The Segmented Worms

These organisms have bodies which are bilaterally symmetrical so that when cut in half lengthwise the two pieces are mirror images of each other. The body consists of rings or segments with non-jointed appendages. Our native species are commercially useful as sport fishing bait and are sought after by professional wormers.

Class *Polychaeta*, The Polychaetes

Clamworm

Nereis virens

A worm commonly about 20cm in length; it has paddle-like appendages which appear as fringes along the edge of each body segment. It is found burrowed into sand or mud. Clamworms actively swarm on the water's surface during the mating season in late March through June.

Bloodworm

Glycera dibranchiata

The blood-red color of this worm is due to its transparent skin which shows its body fluid. The bloodworm can reach 30cm or more in length. Its distinguishing feature is a long, completely withdrawable proboscis. These worms swim only during summer mating. They move and swim in an "S" pattern with rapid, coil-like motions. Bloodworms screw themselves into the sand or mud which they inhabit. This species gets its name from the two small gills attached to each appendage projecting from both ends of each segment.

Phylum *Anthropoda*, Those with Jointed Legs

This is the largest classification of the animal kingdom and represents seventy-five percent of the million or so animal species. Anthropods have a relatively thin exoskeleton covering the body and appendages. This armor coat is segmented to allow for motion and is shed or molted fairly frequently to allow for growth and, in some species, release of eggs or larvae. Anthropods are the most diversely adapted of the animal kingdom with species living in the air, fresh and salt water, on land and underground. Only strictly marine anthropods are included here.

Class *Crustacea*, The Crustaceans

Order *Amphipoda*, The Amphipods

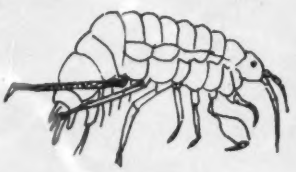
These are small crustaceans, not wide or thick in shape. They are rather thin and high, sometimes arched.

Suborder *Gammaridea*

Beach Fleas

Gammarus talorchestia and *Gammarus orcheslia*

These crustaceans have laterally compressed and arched bodies made up of curved, segmented body parts. They have two antennae, five pair of walking legs, and three pair of abdominal swimming legs. They live high in the intertidal zone, often in the strand line of debris which marks the highest storm tide. They are erratic jumpers.



Scuds

Gammarus genera

These hoppers are superficially similar to the beach fleas but live in intertidal pools and under living seaweed. They swim sideways and make interesting specimens for hand lens or microscopic study.

Order *Cirrepedia*, The Barnacles

These unusual crustaceans live a larval life as a typical crustacean but have very untypical adult existences. As adults they become attached head down inside a limy shell made of six plates. The top of the plate system opens to allow the cirrus, a feathery footlike projection, to grasp and strain food from the water. It is interesting to watch them open and start "fishing" when water flows back to their point of attachment. They live intertidally and compete with blue mussels.

Northern Rock Barnacle

Balanus balanoides

This is the most typical species of the Northern New England Region.

Order *Decapoda*, The Decapods

The tenfeet or decapoda include our best known and most important commercial species; shrimps, crabs and lobsters. These crustaceans have two pair of antennae and five pair of legs on the thorax or chest. The plate covering the head and thorax is fused as one carapace. Feeding appendages such as claws are attached to the head region. Since there will be other small appendages, count walking legs from back to front.

Sandshrimp
Cangon septemspinosa

This is the only common shallow water shrimp in this area. Color is usually drab, but can vary from white to black. It appears to change color to blend with background. The outer antennae of the sandshrimp are as long as its body while the inner, shorter ones are in two parts.

Green Crab
Carcinus maenas

True crabs have a much reduced abdomen which is supported under the carapace or broadened, flat oval shell. The front of the eyes are called frontals and those from the eyes back to the legs are called marginals. Frontal teeth are only those between the eyes. Marginal teeth are counted for one side only. Green crabs have three frontals and five marginals. These crabs are greenish. They grow to about 7cm and live intertidally under stones, in pools, and in seaweed.

Rock Crab
Cancer iroratus

These crabs grow up to 13cm in length. The distinguishing feature is nine marginal teeth rather than five. Rock crabs are very common under rocks and in tidepools. They are usually a drab yellowish brown color.

Lobster
Homarus americanus

This creature is no longer a common shore resident, although historical records describe colonial era settlers picking them up intertidally. Now they are best seen in the tank at the grocers. Lobsters have the usual ten legs and four pairs of walking legs. The forward pair of legs is especially adapted with a large crushing and pinching claw. The lobster size varies to 60cm or larger. Lobsters are now found in the rocky subtidal area just offshore and are increasingly less plentiful.

Hermit Crab
Pagurus longicarpus

This unusual crab has a soft abdomen which is insufficiently armored by nature so that hermits use discarded winkle, whelk and other snail shells as protection. As hermits grow they will select new, larger shells. Hermits use their larger claw as a door when they retract into their shell. The distribution of hermit crabs is worldwide; they usually appear at the lower fringe of the intertidal region and in tide pools. There is a related species of trpical "land" hermit crabs which live their entire adult lives on dry land and will die if left for more than several minutes in water. Since land hermits are popular pets this difference is worth pointing out. Our marine species needs to live underwater.

Class *Arachnida*, The Spider-like Creatures

Horseshoe Crab
Lumulus polyphemus

This creature has blood which resembles that of arachnids although horseshoe crabs were previously classified with crustaceans. The body is composed of three parts; front or cephalo-thorax (rounded horseshoe-shape), and two posterior ends forming points. It has large compound eyes and small simple eyes near the center line of the shell. Underneath are found gills. It has five pair of legs with pincer-like claws and a long pointed tail which is used for turning over, not for defense. This harmless creature is not a crab at all. It lives on sandy or muddy shores often below the low tide mark. It breeds in early summer near the high tide mark.

Phylum *Echinodermata*, The Spiney-skinned Animals

This phylum includes starfish, sea cucumbers, sea urchins, and sand dollars. Adults have a spoke-like or radial symmetry with some species having radiating sections called arms. The skeleton is limey and is internal, usually with projecting spines. Most species have a mode of locomotion made up of water filled tubes and suction-cup-like tube feet.

Class *Stelleroidea*, The Sea Stars

Common Starfish
Asterias forbesi and *Asterias vulgaris*

Species identification of these purple colored stars is for experts. Usually 15-30cm in diameter, they have five arms but can change to more or fewer because of loss or regeneration. The top or dorsal skin is rough with close interlocking spines. The center eyespot, maduperite silverplate, may be bright orange. Underside has four rows of tube feet. They are found in tidal pools, under rockweed, and subtidally. Dried specimens can often be found in the flotsam or high tide mark debris.

Class *Echinoidea*, The Egg-shaped Creatures

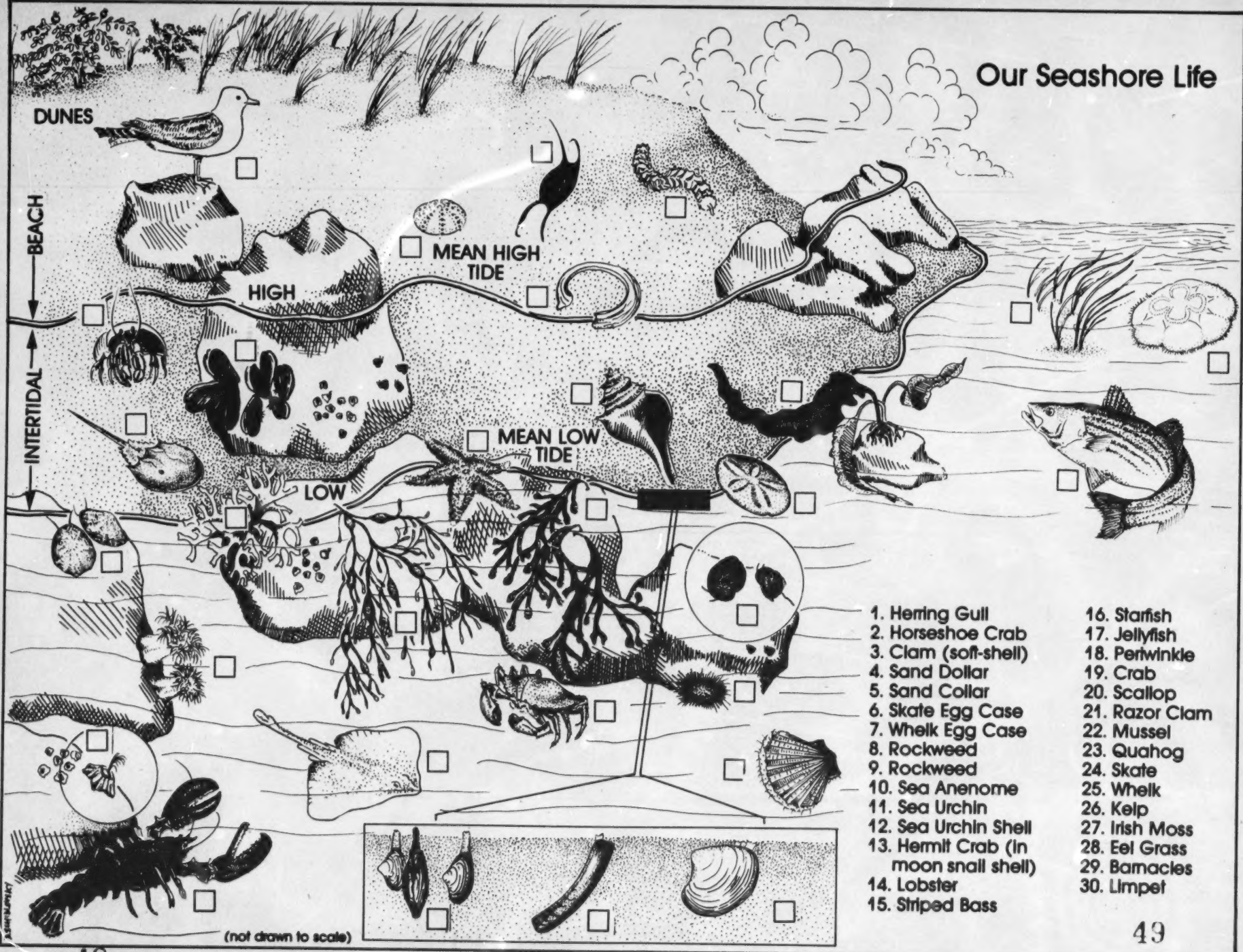
Green Sea Urchin
Strongylocentrotus droebachiensis

This spherical creature can be up to 10cm in diameter, is flattened on the oral side, and has short blunt spines. Its spines give it a bright green color, but the dried spineless shell is off-white. The urchin is usually subtidal but sometimes becomes stranded at low tide or can be found in tidepools and under rockweed. Very often cleaned out, fresh shells are found among the rocks above the intertidal zone where sea gulls have dropped them to crack open the shells. They yellowish egg mass is considered a delicacy by some.

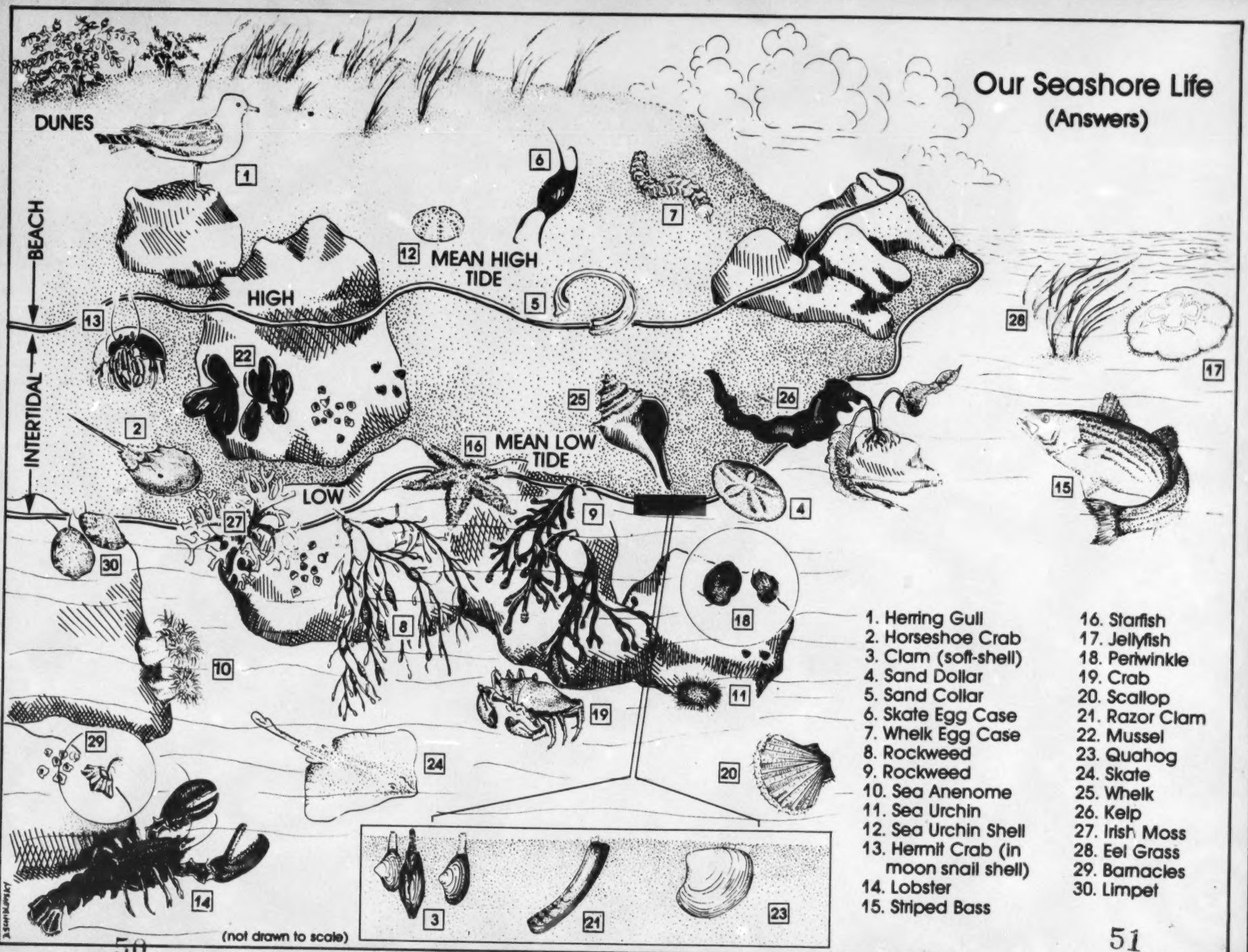
Sand Dollar
Echinarachnius parma

This flat echinoderm has a shell up to 8cm in diameter. Spines are numerous but short and hairlike. The mouth is underneath with the anus on top. It lives usually subtidally on sandy or muddy bottoms although it can be found washed up on shore or in tidepools.

Our Seashore Life



1. Herring Gull
2. Horseshoe Crab
3. Clam (soft-shell)
4. Sand Dollar
5. Sand Collar
6. Skate Egg Case
7. Whelk Egg Case
8. Rockweed
9. Rockweed
10. Sea Anenome
11. Sea Urchin
12. Sea Urchin Shell
13. Hermit Crab (in moon snail shell)
14. Lobster
15. Striped Bass
16. Starfish
17. Jellyfish
18. Periwinkle
19. Crab
20. Scallop
21. Razor Clam
22. Mussel
23. Quahog
24. Skate
25. Whelk
26. Kelp
27. Irish Moss
28. Eel Grass
29. Barnacles
30. Limpet



Our Seashore Life
(Answers)

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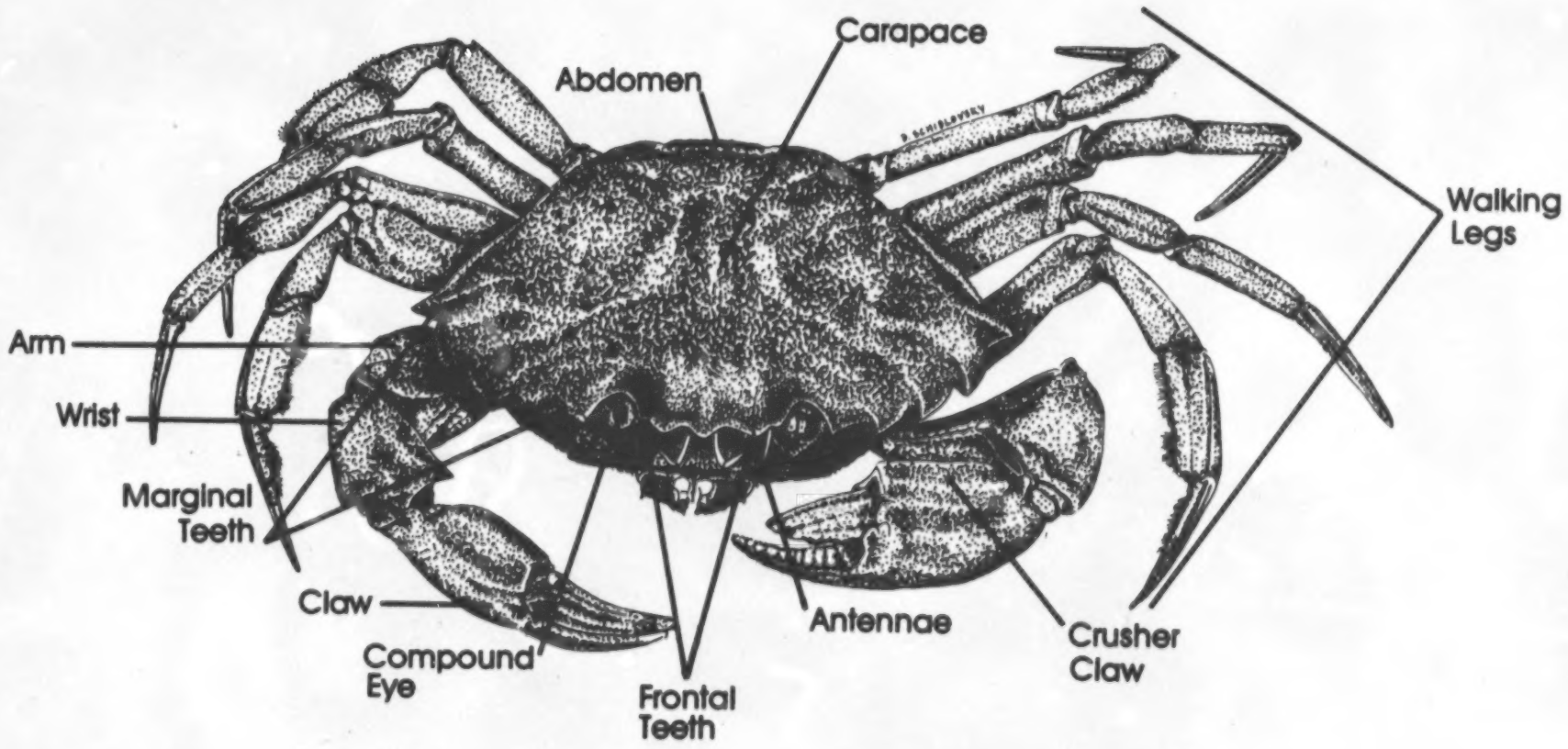
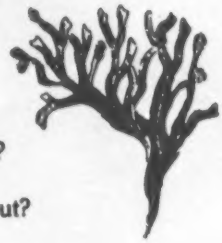
Green Crab


Carapace
Abdomen
Walking Legs
Arm
Wrist
Marginal Teeth
Claw
Compound Eye
Frontal Teeth
Antennae
Crusher Claw

A Field Guide to Questions about Seashore Life

Rockweed, *Fucus vesiculosus*



Where is this algae found?
What color is it?
How does it float?
Are there other plants growing near it?
How do you think it grows?
Squeeze an air bladder, what comes out?

Knotted Wrack, *Ascophyllum nodosum*

How does this plant get its name?
Can you find its air bladders?
Describe the shape of this plant?
How does this plant hold on in rough surf?

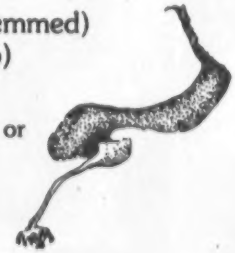
Irish Moss, *Chondrus crispus*

What color is this?
Are there other plants and animals on this plant?
Why do people collect this?
Look down on the low tide area for these plants.

Sea Lettuce, *Ulva lactuca*

Look in the upper tide pools for this.
What does it look like?
How does it get its material for growth?

Kelps, *Laminaria longicrunis* (hollow stemmed)
Laminaria digitala (horsetail kelp)



Kelps are growing down on the water's edge.
Why don't the seaweeds need true roots, stems or leaves?
Look for dried parts in the flotsam line.

Laver, *Porphyra umbilicalis*
Tufted Redweed, *Gigartina stellata*
Coralline Algae, *Corallina officinalis*
Dulse, *Rhodymenia palmata*

These are red algae.
What use are they to you?
Look way down on the water's edge for them.

Dog Whelk, *Thais lapillus*

How is this animal different from the periwinkle?
Look up around the barnacles for this animal.
What does it feed on?
You will find its eggs in the late spring.
Look under the seaweed for them.
How many shells does this animal have?
Look at the shells opening with a hand lens. What do you see?

Blue Mussel, *Mytilus edulis*

Where are these mussels found?
Are there any other animals like this?
How is this animal attached to rocks?
Try to pull one off. Look at the attachment with a hand lens.

Periwinkle, *Littorina littorea*

Where are these animals found?
What do they feed on?
What does it use its trap door for?
When the door is open what does it look like?
Can you find its head?
How does it move about?
How do these snails move?
Do they like light or dark places?
How fast can they go?

Barnacle, *Balanus balanoides*

This animal is not a member of the clam and whelk group.
What does it have that are like these animals? Different?
Watch these animals in a tidepool.
How do they feed?
Can they move?

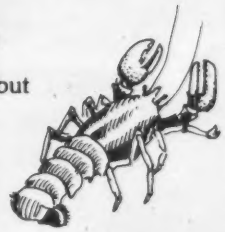
Limpet, *Acmaea testudinalis*

How many shells does it have?
Find its strong muscular foot.
How does it use its foot?
Where is the head?
Where does it live?
How is it able to live the way it does?

Green Crab, *Carcinus maenas*

Turn over the rockweed and you will find this animal.
How many legs does it have?
What does it eat?
Describe its home.
How does this animal breathe?
How does it see?
Count its marginal teeth.
Do you find crabs with more?

American Lobster, *Homarus americanus*

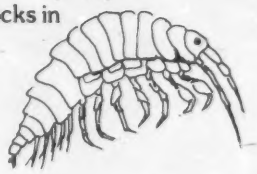


You may not find a lobster in the rocky shore areas but you may find parts of him.
He usually lives in deeper water.
How does a lobster move?
What kinds of things does it eat?
Describe where it might live.

Hermit Crab, *Pagurus longicarpus*

You will find hermit crabs in intertidal pools.
Where does this animal get its shell?
What is he like without his shell — don't remove!
Watch this animal carefully.
How does it react when another hermit crab comes near it?
Try it!

Scud, *Gammarus genera*

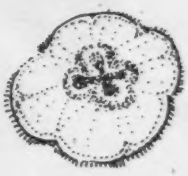


This animal is not an insect.
If this is so, who are its relatives?
You will find these animals when you turn over rocks in the intertidal pools.
Where else does it live?
How do they move?

Crumb Of Bread Sponge, *Halichondrea*

Is it a plant or animal?
How does it live?
What color is it?
Are there other plants or animals in it?
Watch its openings with a hand lens.

Moon Jelly, *Aurelia aurita*



You may find this washed up on shore.
What kind of an animal is this?
Where does it usually live?
How does it eat?

Sea Urchin, *Strongylocentrotus droebachiensis*

How is the sea urchin protected from its predators?
Usually one only finds the skeleton (test) of this animal.
What does the shape of this animal resemble?
How does it move?
Where is its back?
Where is its mouth?
Turn it over on its back.
What does it do?

Common Starfish, *Asterias forhesi*

How does a starfish breath?
How can it eat?
What is the eye spot really for?
Can a starfish see to find its food.
How does it move?

Sand Dollar, *Echinarachnius parma*

You may only find the skeleton of this animal.
How is this animal like a sea urchin?
Where is the mouth?

Razor Clam, *Ensis Directus*

How does the animal get its name?
What other animals are similar to it?
Where does it usually live?
How does it move?